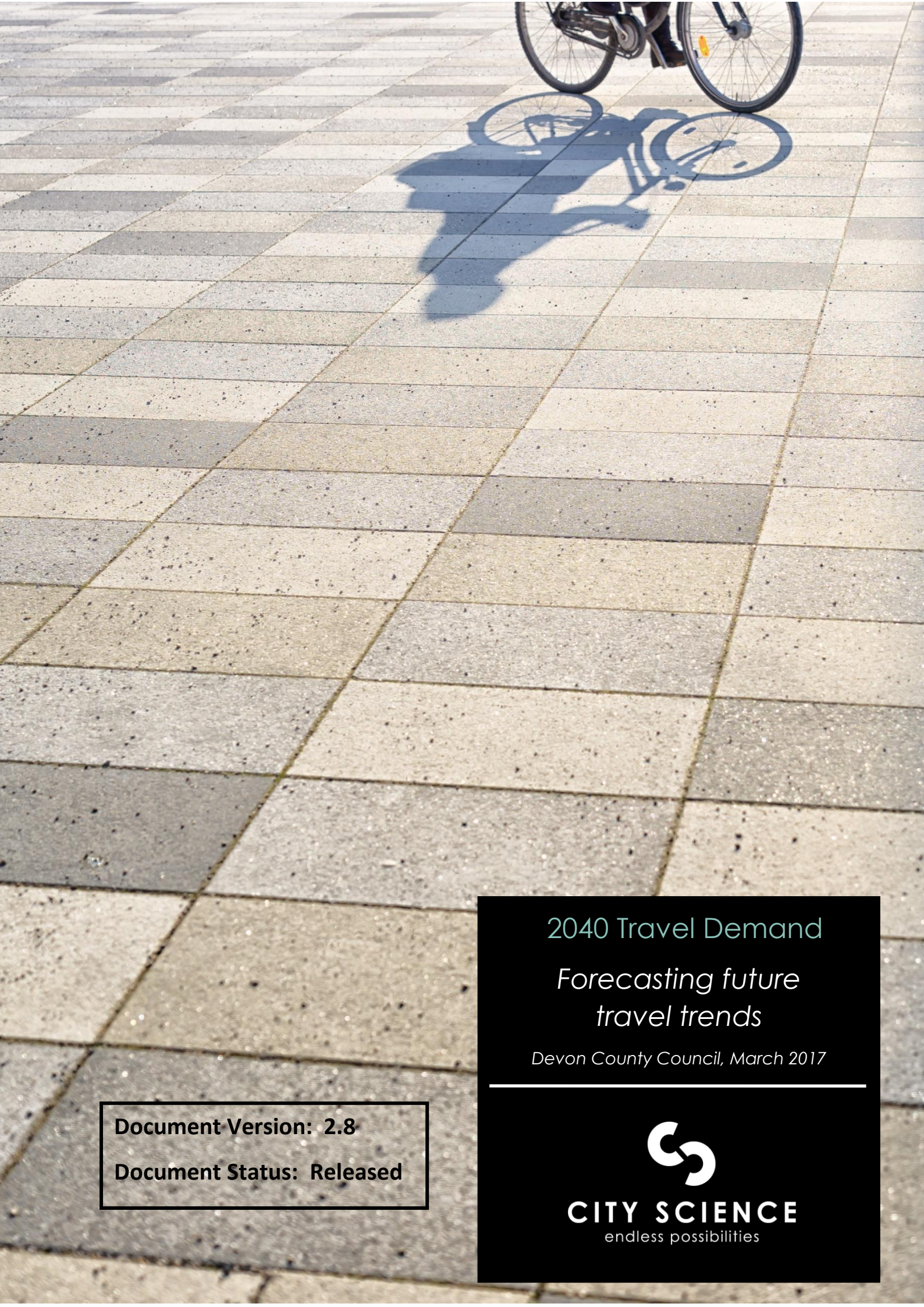

2040 Travel Demand

Forecasting future travel trends

Devon County Council, March 2017

Document Version: 2.8

Document Status: Released

CITY SCIENCE

endless possibilities

CITY SCIENCE
endless possibilities

Contents

CITY SCIENCE
endless possibilities

List of Figures

CITY SCIENCE
endless possibilities

List of Tables

CITY SCIENCE
endless possibilities

2040 Travel Demands

Forecasting Future Travel Trends

1 Executive Summary

1.1.1 This study provides a range of demand forecasts for travel to work demand over the time horizon of the current Greater Exeter Strategic Plan (GESP). The report provides a review of historic datasets to better understand the scale and drivers of commuter travel into and out of Exeter in the peak period. This analysis then provides the basis for considering future demand, providing a quantitative guide to the likely scale of future travel demand resulting from anticipated population changes over the GESP planning horizon.

1.2 Analysis of Background Information

1.2.1 According to the Journey to Work (JTW) census in 2011, there was a total of 74,818 daily inbound commuter trips into and within Exeter across all modes. Of these trips, 37,151 (50%) originated from areas outside the city, with a further 37,667 generated within the city. In the same year there were 95,771 trips ending in Greater Exeter (Teignbridge, Mid Devon and East Devon)[1] on a daily basis across car and non-car modes. Of these trips, 71,329 (74.5%) also started in Greater Exeter.

1.2.2 The total number of daily inbound commuter trips with a destination in Exeter increased by 10.9% between the 2001 and 2011 census, a gross increase of 7,360 trips. The total number of daily trips ending in Greater Exeter however declined by 3.1% between the 2001 and 2011 census. Within Exeter, the city centre area saw an overall decrease in daily inbound trips, while the most significant growth was in areas around the Met Office, RD&E Wonford, Exeter Business Park, the University of Exeter, Sowton Industrial Estate and Pynes Hill Court. With the exception of the RD&E, these growth areas are located on the peripheries of the Exeter local area district.[2]

Mode	From Home	To Work	2001 Trips	(%)	2011 Trips	(%)	Absolute Change	% Change
Car	Exeter	Exeter	21,261	31.5%	17,363	23.2%	(3,898)	(-18.3%)
	Greater Exeter		19,888	29.5%	22,966	30.7%	3,078	15.5%
	Outside		5,917	8.8%	8,123	10.9%	2,206	37.3%
Non car	Exeter		16,713	24.8%	20,304	27.1%	3,591	21.5%
	Greater Exeter		2,830	4.2%	4,460	6.0%	1,630	57.6%
	Outside		849	1.3%	1,602	2.1%	753	88.7%
Total			**67,458**	**100.0%**	**74,818**	**100.0%**	**7,360**	**10.9%**

Table 1: Change between 2001 and 2011 for destinations in Exeter grouped by mode

[1] See section 7.1 for geographic definitions of areas considered in this report.
[2] See Figure 12: Heat map showing the differences in travel to work destination counts

1.2.3 Within Exeter, the estimated demand for commuter car trips has risen by 4.2% across the peak period of travel (7am-9am and 4pm-6pm) between 2001 and 2011[3]. In absolute numbers, demand for car trips has increased by 1,156[4] in the morning peak and 1,500 in the evening peak.

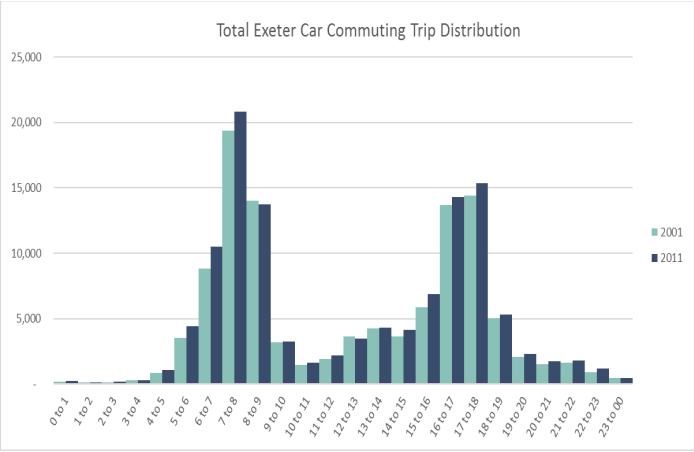

Figure 1 Total Exeter Car Commuting Trip Distribution

Time	Estimated Total Trips 2001	2011	% Change
6 to 7	8,846	10,478	18.45%
7 to 8	**19,362**	**20,823**	**7.55%**
8 to 9	14,037	13,732	(-2.17%)
9 to 10	3,206	3,254	1.49%
15 to 16	5,861	6,884	17.45%
16 to 17	13,688	14,311	4.55%
17 to 18	**14,427**	**15,362**	**6.48%**
18 to 19	5,037	5,333	5.88%

1.2.4 Mode shares within Exeter are markedly different from those within the rest of the study area. Trips originating from Exeter show a significant proportion of walking: 24.1% of trips generated are on foot, compared to the national average of 10.9%. Greater Exeter, however is heavily car-dependent with 71.6% of trips generated being car-based, compared to the national average of 60.7%. Use of public transport is generally lower than the national average of 17.7%, with 11.9% in Exeter and 5.6% in Greater Exeter.

1.2.5 A number of trends can be observed between 2001 and 2011 that feed into the modelling in this report. Trip generation per person declined in Exeter but rose in Greater Exeter. Falling trip rates have been observed in other urban areas and this may be a trend that influences future demand within the city. The percentage share of car trips has declined both for journeys originating in Exeter and Greater Exeter, but in Greater Exeter this masks an absolute increase in car trips.

		2001	2011	Change
Journeys originating in Exeter	% Share car journeys	57.2%	50.2%	(-7.0%)
	Absolute car journeys	29,767	28,836	(931)
	Absolute non-car journeys	22,303	28,591	6,288
	Total journeys in Exeter	**52,070**	**57,427**	**5,357**
Journeys originating in Greater Exeter	% Share car journeys	66.5%	64.7%	(-1.8%)
	Absolute car journeys	93,643	102,776	9,133
	Absolute non-car journeys	47,105	56,097	8,992
	Total journeys in Greater Exeter	**140,748**	**158,873**	**18,125**

Table 2: Change in car journeys originating in Exeter and Greater Exeter

[3] Census recorded demand for car-based travel to work, for journeys starting or ending within Exeter. See section 4.2.3 .
[4] Refers to the 7am-9am period of the morning peak

1.3 Future Travel Demand

1.3.1 Future projections are always subject to a high degree of variability and can be influenced by a range of drivers. This study examines the relationships observed within national datasets to develop future forecasts for Greater Exeter. Key factors modelled include population, age, economic activity, occupation and car availability. The impact of other influencing trends, such as the increase in Light Goods Vehicles, is also discussed.

1.3.2 The range of future demand projections is developed based on population forecasts provided by Devon County Council. Population is a key driver of trip demand and therefore trip-rate forecasts depend on the reliability of the population forecasts used. Forecast population growth provides some important context to the projected increases in journey demand. The base-line scenario outlined below includes as a driver assumed population growth of 43.1% in Exeter and 6.9% in Greater Exeter to 2040 (compared to 2011).

1.3.3 The modelled base-case projects demand for commuting trips into and within Exeter of 96,000 in 2040 (an increase of 28% compared to the 2011 census JTW data). We forecast demand for 43,000 commuting trips coming from outside of Exeter (a 15.7% increase), and 53,000 trips starting and ending within the city. Demand for commuting trips to Greater Exeter is forecast to be 114,000, an increase of 19.0% from 2011. It is forecast that 74.6% (85,000) of these trips would be generated within Greater Exeter itself.

1.4 From Travel Demand to Observation

1.4.1 Journey to Work data, upon which this study is based, provides demand levels for commuting trips and is collected by survey and not observation. As a result of the way the survey is captured, holidays, sick leave and the effect of non-work days are not included in the numbers presented and actually reduce the levels of commuting activity that will be observed on the road. We observe that depending on the specific assumptions made, observed trips may be ~30% lower than those shown within the census Journey to Work data.

1.4.2 In this study, we present both unadjusted and adjusted views of our model outputs. The unadjusted view shows figures that are comparable with the census JTW datasets. The adjusted forecast takes into account the effects mentioned above and is more comparable with the National Trip End Model (NTEM), an important national forecasting tool. Due to its importance, we also present forecasts that are comparable with the NTEM data.

1.4.3 Figure 2 shows model outputs that include adjustments to be comparable with the NTEM in the base year. It can be observed that the NTEM forecasts lower trips than the model developed herein. Further analysis reveals that a key driver of this is the difference, in particular in Exeter, of the population forecasts used. Figure 3 shows the comparison between the latest Devon County Council forecasts and the ONS projections (red line) used in NTEM.

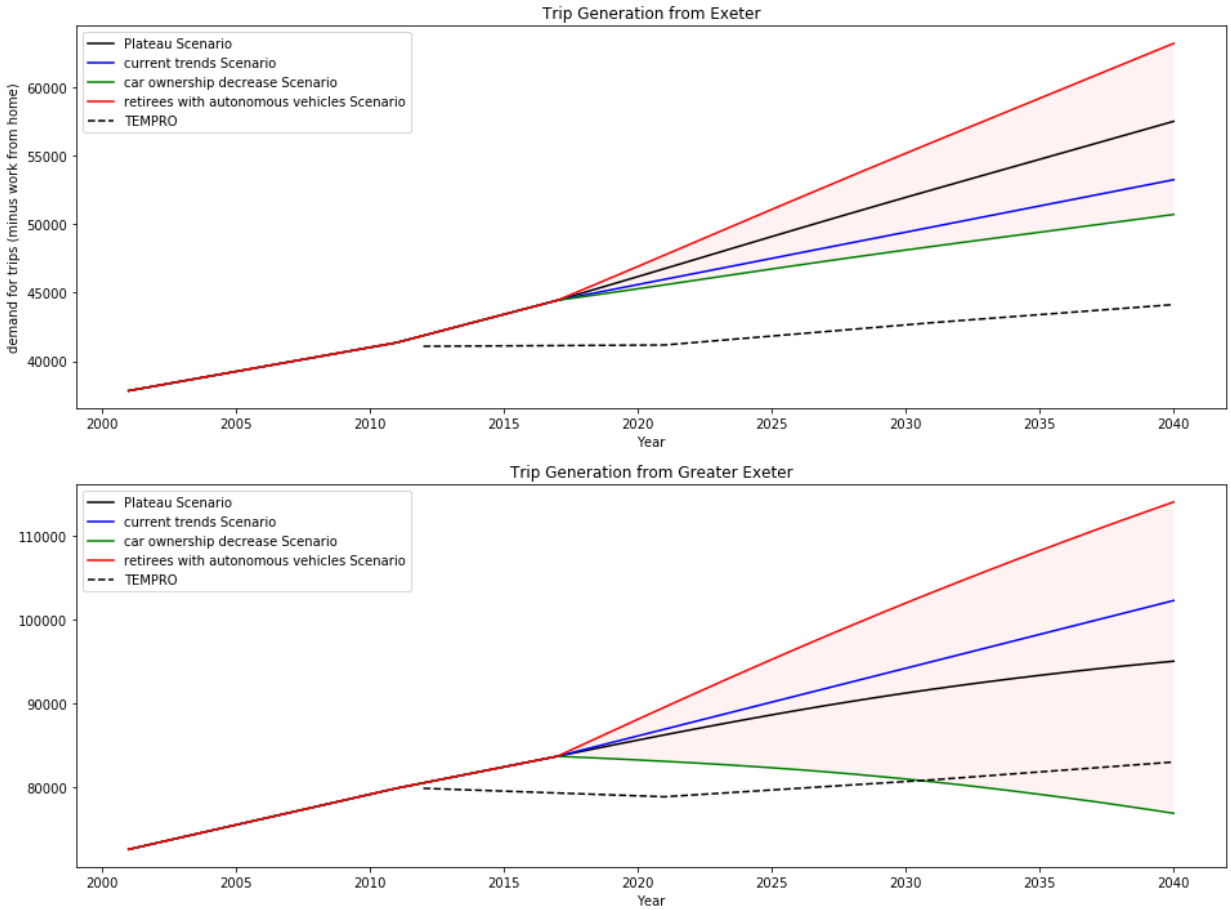

Figure 2: 2040 Model 2 Adjusted forecast scenario fan chart (all outbound commuter trips)

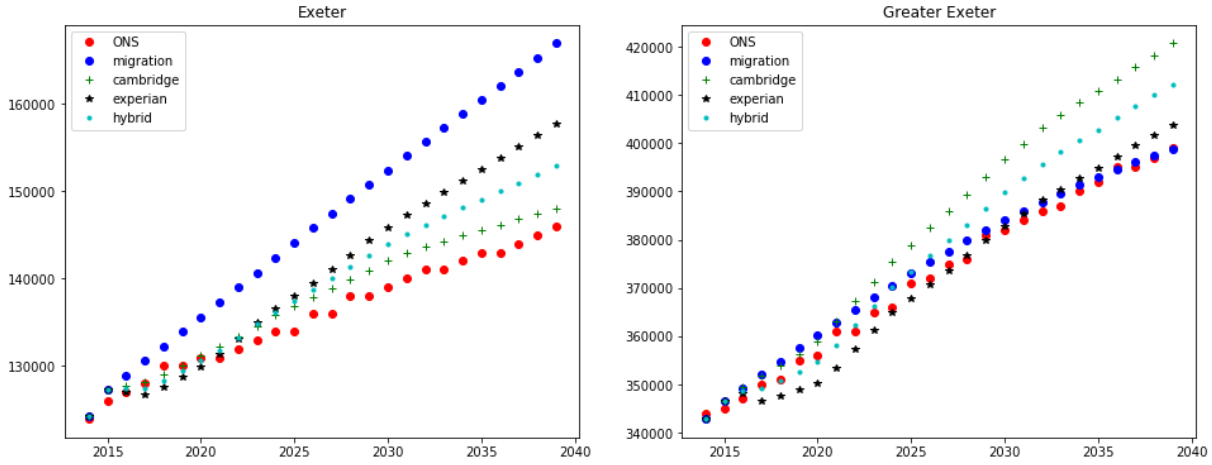

Figure 3: NTEM (ONS) Population Growth compared to DCC Forecasts

2 Part 1: Overview of Historic Demand Data

2.1 Introduction

2.1.1 As part of the evidence base being developed for the Greater Exeter Strategic Plan (GESP), Devon County Council (DCC) are producing and commissioning a series of analyses of trip trends and transport activity patterns. As part of this activity, DCC requires an evidence base to assess Future Travel Demand to provide a quantitative guide to the likely scale of future trips into and within Exeter (and districts in the Greater Exeter area).

2.1.2 This report focuses on demand for travel to work trips, utilising a range of datasets and historical patterns to develop transport demand forecasts based on population and employment projections. The study employs a series of forecasting approaches and scenarios to present a range of future demand profiles linked to different sets of underlying assumptions. The models developed have been provided, where complexity allows, within the associated Excel spreadsheet.

2.1.3 The study begins with an overview of historic patterns and trends observed in data obtained from ONS, National Travel Survey, CitiLogik and local traffic counters validated with other sources where appropriate. The report then provides an overview of relationships observed in national data that can help predict future demand. Two models are then presented and applied to total trips and car trips. In each case, a range of possible scenarios are explored and for completeness, predictions are compared against the National Trip End Model.

2.1.4 Detailed notes on the data methodology are provided in section 7. Note that Destination-based analysis excludes trips described as “Working from home” whereas they are included in origin-based analysis.

2.2 2001 Travel Demand into Exeter

2.2.1 Travel to work demand for Exeter-based destinations

According to the census in 2001, there was a total of 67,458 daily trips into and within Exeter across car and non-car modes. Of these trips, 29,484 (44%) originated from areas outside the city, with a further 37,974 (56%) generated within the city indicating a high degree of intra-city travel. 34% of trips were from Greater Exeter with the remaining 10% originating from outside the study area.

From Home	To Work	Mode	2001 Trips	(%) by areas	(%) by mode
Exeter	Exeter	Car	21,261	56%	32%
		Non-Car	16,713		25%
Greater Exeter		Car	19,888	34%	29%
		Non-Car	2,830		4%
Outside		Car	5,917	10%	9%
		Non-Car	849		1%
Total			**67,458**	**100%**	**100%**

Table 3: Travel to work demand for Exeter-based destinations in 2001

2.2.2 Mode share for trips to destinations in Exeter

Of the trips with destinations in Exeter in 2001, 70% were car-based journeys. As distances become larger, car journeys occupy a greater percentage of the mode share, for example, car journeys represented 88% of trips with origins in Greater Exeter and outside the study area.

2.3 2011 Travel Demand into Exeter

2.3.1 Travel to work demand for Exeter-based destinations

According to the census in 2011, there was a total of 74,818 daily trips into and within Exeter across car and non-car modes. Of these trips, 37,151 (50%) originated from areas outside the city, with a further 37,667 generated within the city. 37% of trips were from Greater Exeter with the remaining 13% originating from outside the study area.

From Home	To Work	Mode	2011 Trips	(%) by area	(%) by mode
Exeter	Exeter	Car	17,363	50%	23%
		Non-Car	20,304		27%
Greater Exeter		Car	22,966	37%	31%
		Non-Car	4,460		6%
Outside		Car	8,123	13%	11%
		Non-Car	1,602		2%
Total			**74,818**	**100%**	**100%**

Table 4: Travel to work demand for Exeter-based destinations in 2011

2.3.2 Mode share for trips to destinations in Exeter

In 2011, of the total trips ending in Exeter, 65% were car journeys. While non-car journeys represent the majority (54%) of journeys starting and finishing within the city, as distances become larger, car journeys occupy a greater share of the mode. In 2011, car journeys represented 83.6% of trips with origins in Greater Exeter and beyond the study area.

2.2.3 In 2001, for all trips with destinations in Exeter (Travel into Exeter in Figure *4*), the majority of commuting (71.4%) was by Private Vehicle, close to the national average at that time of 69.6%. Commuting by foot was 13.5% which compares favourably with the national average of 10.3%. Public transport usage was lower than observed nationally with Buses, Trains and Metro modes accounting for 11.0%, compared to 16.2% in the national data.

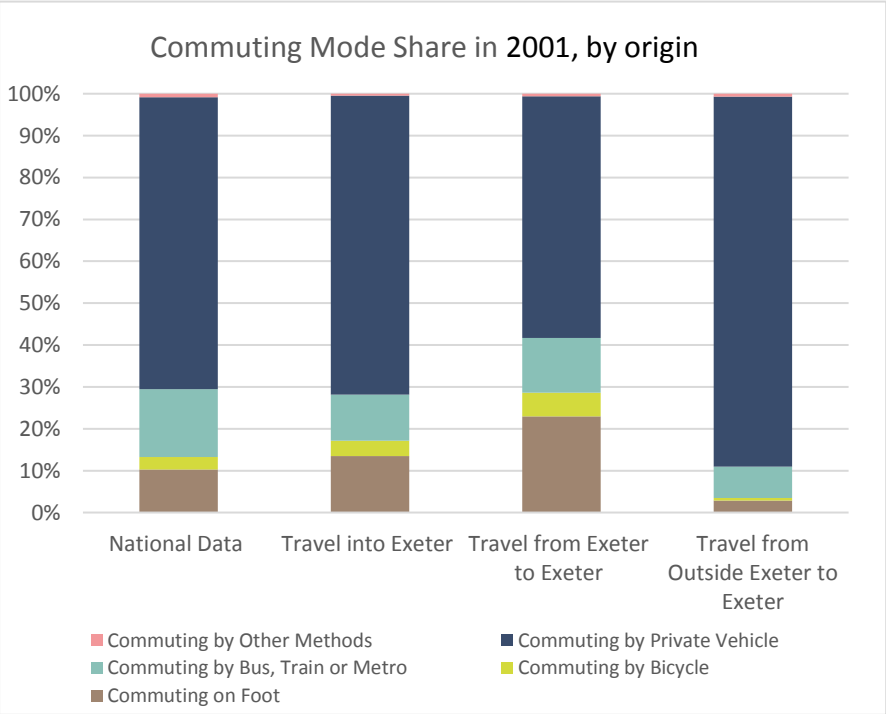

Figure 4: National, Travel into Exeter, Exeter to Exeter & Outside Exeter to Exeter commuting mode shares in 2001

2.3.3 In 2011, for all trips with destinations in Exeter (Travel into Exeter in Figure 5), the majority of commuting (66.2%) was by Private Vehicle, slightly below the national average in that year of 67.1%. Commuting by foot was 16.5% which compared favourably with the national average of 10.9%. Public transport accounted for 11.9% of travel, lower than the national average of 17.7%.

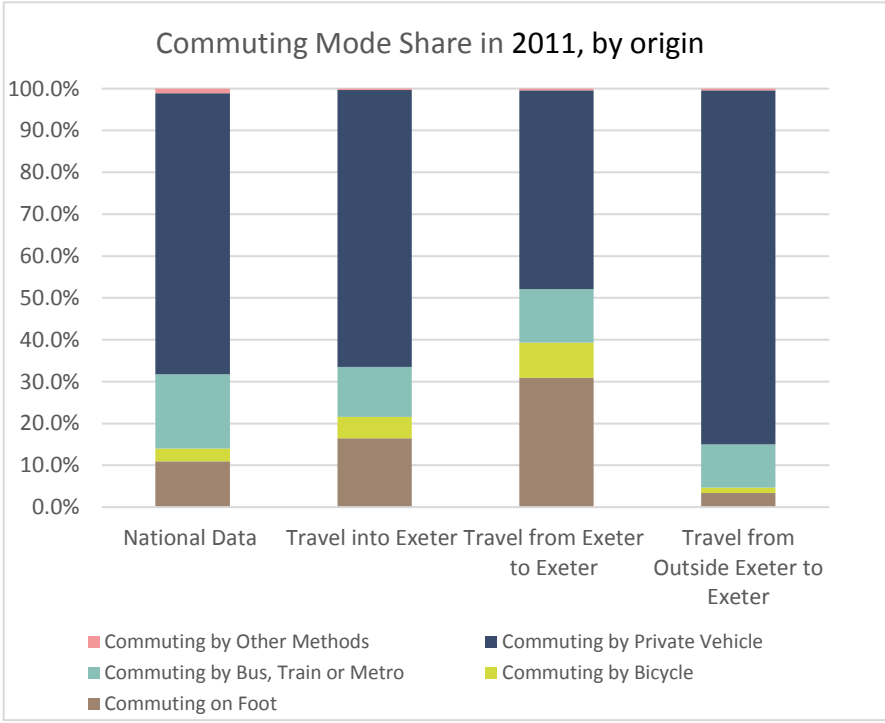

Figure 5: National, Travel into Exeter, Exeter to Exeter & Outside Exeter to Exeter commuting mode shares in 2011

2.2.4 Features of trips as they arise by origin zone give additional insight into the modal preferences by production zone. A detailed analysis on this basis is included in the accompanying Excel spreadsheet. In particular, this shows that trip production from Exeter exhibited a very high percentage (19%) of walking trips on a comparable basis (excluding working from home). Car trips from Exeter origins were 54.5% on a comparable basis, compared to the national share of 61.7%.

2.3.4 For outbound trip origins in Exeter, the share of car journeys fell to 49.2% in 2011 compared to the national average which had declined to 60.7%. The share of walking for outbound trips originating in Exeter had increased to 24.1% compared to the national average of 10.9%.

2.4 2001 Travel Demand into Greater Exeter

2.4.1 Travel to work demand for Greater Exeter-based destinations

According to the census, in 2001, a total of 98,821 trips had destinations in Greater Exeter on a daily basis across car and non-car modes. Of these trips, the vast majority (80%) were from origins within Greater Exeter. Only 7% was outbound traffic coming from Exeter-based origins and the remaining 13% came from outside the study area.

From Home	To Work	Mode	2001 Trips	(%) by areas	(%) by mode
Exeter	Greater Exeter	Car	5,903	7%	6%
		Non-Car	909		1%
Greater Exeter		Car	56,854	80%	58%
		Non-Car	22,039		22%
Outside		Car	11,733	13%	12%
		Non-Car	1,383		1%
Total			**98,821**	**100%**	**100%**

Table 5: Travel to work demand for Greater Exeter-based destinations in 2001

2.4.2 Mode share for trips to destinations in Greater Exeter

Of the trips with destinations in Greater Exeter in 2001, 75% were car journeys. For journeys starting and ending within Greater Exeter, the share of car-based travel was 72%. As distances become longer, the share of car-based trips increases: 86% of journeys from Exeter to Greater Exeter and 89% of journeys from outside the study area.

2.5 2011 Travel Demand into Greater Exeter

2.5.1 Travel to work demand for Greater Exeter-based destinations

According to the census in 2011, there were 95,771 outbound trips ending in Greater Exeter on a daily basis across car and non-car modes. Of these trips, 71,329 (74.5%) also started in Greater Exeter. The majority of the remaining 24,442 trips came from outside the study area with only 8% of total trips originating in Exeter.

From Home	To Work	Mode	2011 Trips	(%) by area	(%) by mode
Exeter	Greater Exeter	Car	6,022	8%	6%
		Non-Car	1,513		2%
Greater Exeter		Car	50,464	74%	53%
		Non-Car	20,865		22%
Outside		Car	14,503	18%	15%
		Non-Car	2,404		3%
Total			**95,771**	**100%**	**100%**

Table 6: Travel to work demand for Greater Exeter-based destinations in 2011

2.5.2 Mode share for trips to destinations in Greater Exeter

Of the total trips with destinations in Greater Exeter, 74.1% were car journeys. Car journeys also represented 70.7% of journeys that starting and finishing in the region. For trips originating in Exeter and outside the study area, car journeys represented 84.0% of the mode share.

2.4.3 For trips with destinations in Greater Exeter, the majority of commuting (77.2%) was by Private Vehicle, compared to the national average of 69.6%. Commuting by foot was 15.3%, again above the national average of 10.3%. Bus, Tram and Metro usage however accounted for only 3.7% of journeys, considerably lower than the national average of 16.2%.

2.4.4 Origin-based analysis of Greater Exeter in 2001, shows that of journeys starting in the area, 70.8% are car-based compared to the national average of 61.7%. Bicycle trip production share was also slightly lower than the national average.

2.5.3 When considering all private vehicles, the majority of commuting to Greater Exeter 75.5% was observed to be in this mode. This compares to the national figure of 67.1% in the same year. Commuting by foot, at 16.9% compared favourably to the national average of 10.9% and the Exeter figure of 16.5%. Use of public transport (Bus, Tram and Metro) however, accounted for only 4.3% of journeys compared to the national average of 17.7%.

2.5.4 The predominance of car journeys is apparent also when considering Greater Exeter's trip production where 71.6% of trips were car journeys, compared to the national average of 60.7%. Public transport trips originating from Greater Exeter were 5.6% compared to 17.7% at the national level.

2.6 Spatial distribution of commuting demand in 2001

2.6.1 Commuting Attractors in 2001

Figure 6 below shows the distribution of all commuting destinations for trips ending in the Study Area. Exeter's dominance can be clearly seen, as can the influence of the radially dispersed towns of Exmouth, Sidmouth, Honiton, Tiverton-Cullompton, Crediton and Newton Abbot-Bovey Tracey.

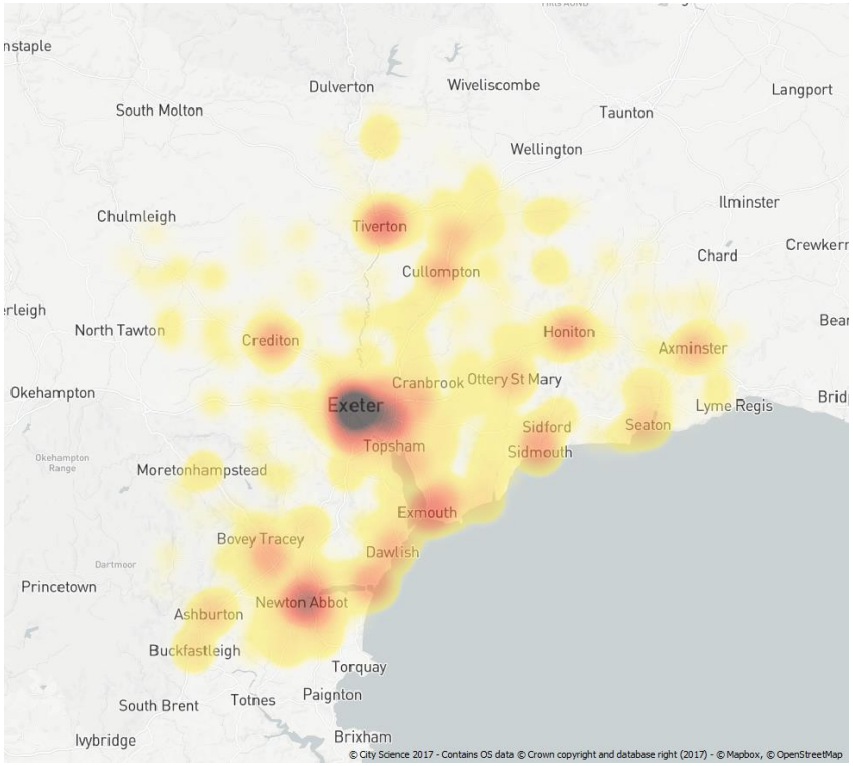

Figure 6: Distribution of trip-ends within the study area from all origins in 2001

2.7 Spatial distribution of commuting demand in 2011

2.7.1 Commuting Attractors in 2011

Figure 9 shows the distribution of all commuting destinations for trips ending in the Study Area. The image mirrors the 2001 map with Exeter being the dominant attractor and the relative influence of the radially dispersed towns remaining largely similar although some of the smaller rural attractors can be seen to have diminished in importance.

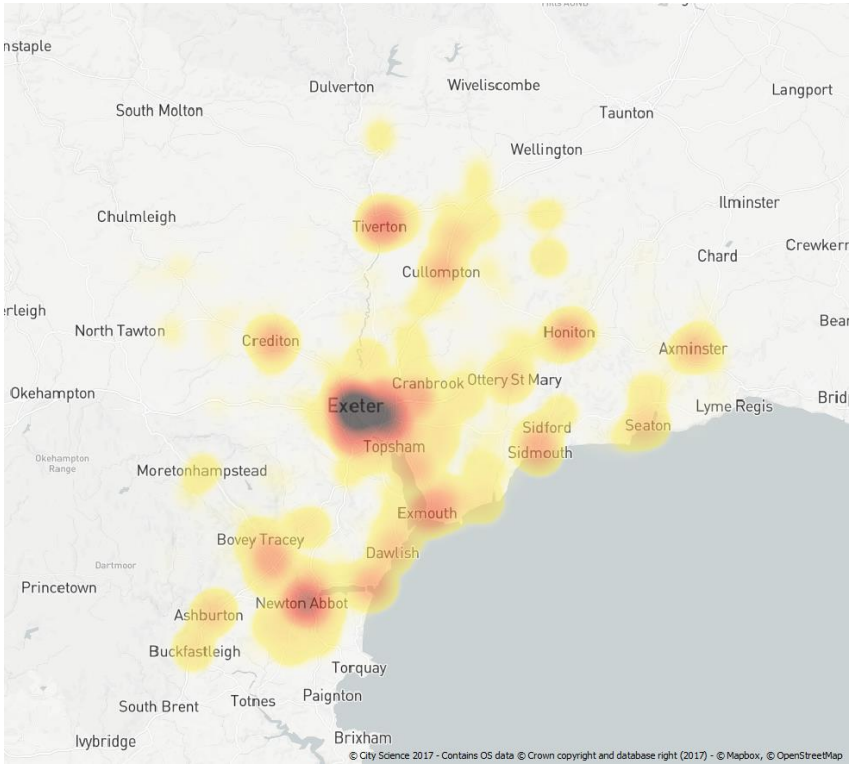

Figure 9: Distribution of outbound trip-end destinations within the Study Area in 2011

2.6.2 Important Trip Production / Outbound Trip Origin Zones

A similar exercise can be undertaken looking at where trips are originating from. Figure 7 below shows the origins for the trips ending within Exeter. Here a similar spatial pattern is observed, but what is again noticeable is the number of Exeter trip-ends originating within the city itself.

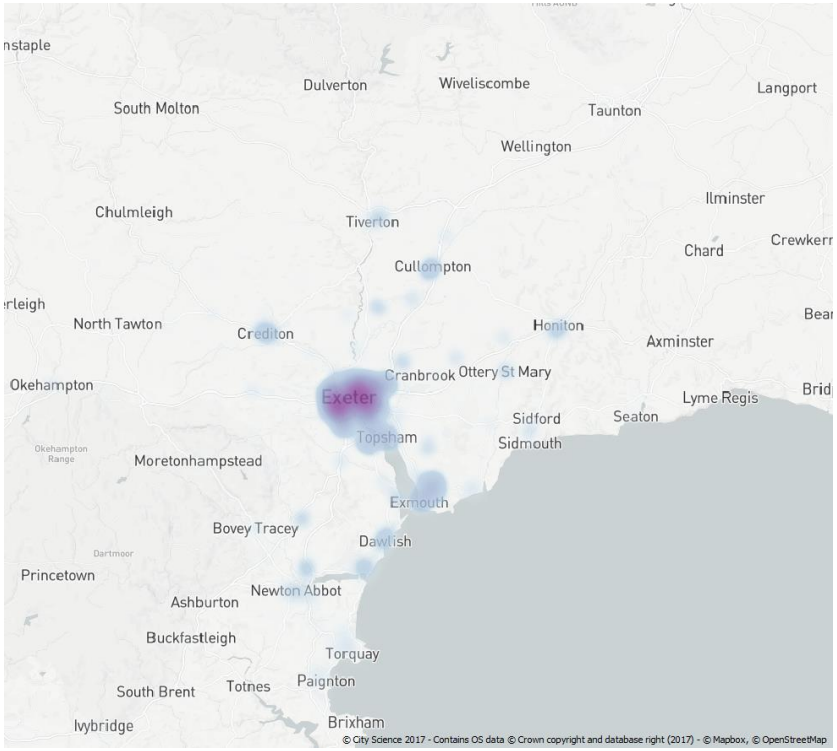

Figure 7: Distribution of origins (production zones) for trips ending in Exeter (2001)

2.7.2 Important Trip Production / Origin Zones

A similar exercise was undertaken to update the trip production maps (Figure 10). Overall the spatial distribution of origins to both Exeter and the Study area appears relatively stable between 2001 and 2011. Modest changes can be observed with the heat map of outbound commuting origins in Okehampton and Plymouth showing a minor increase between the two charts and their 2001 equivalents.

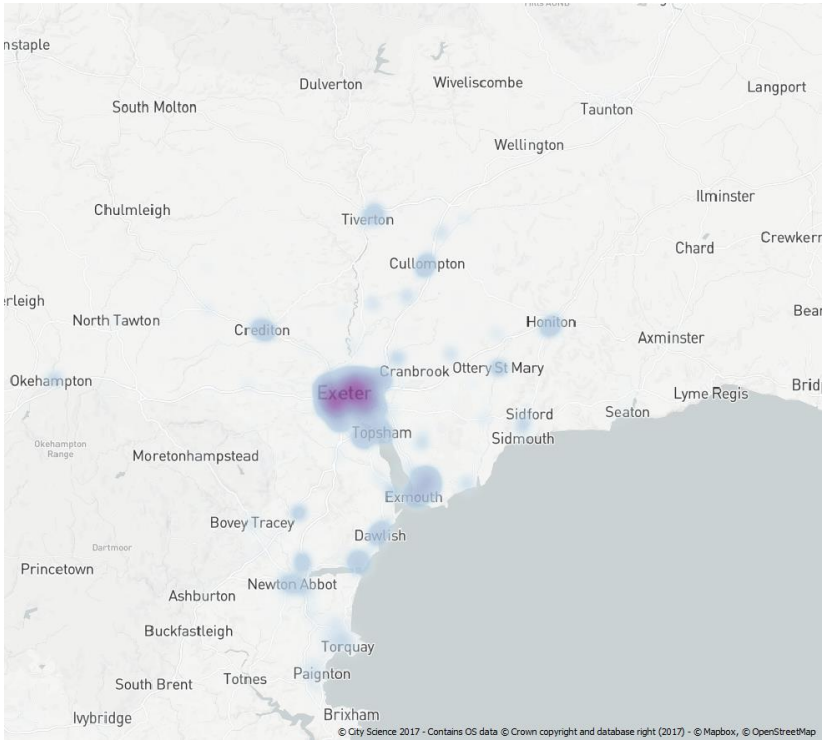

Figure 10: Distribution of production zones for trips with an attractor in Exeter in 2011

2.6.3 Figure 8 below provides a plot of the production locations (where trips are coming from) for all destinations within the Study Area in 2001. Here it can be observed, that for 2001, with the exclusion of Torbay, the majority of commuting trips ending in the study area originate within the study area.

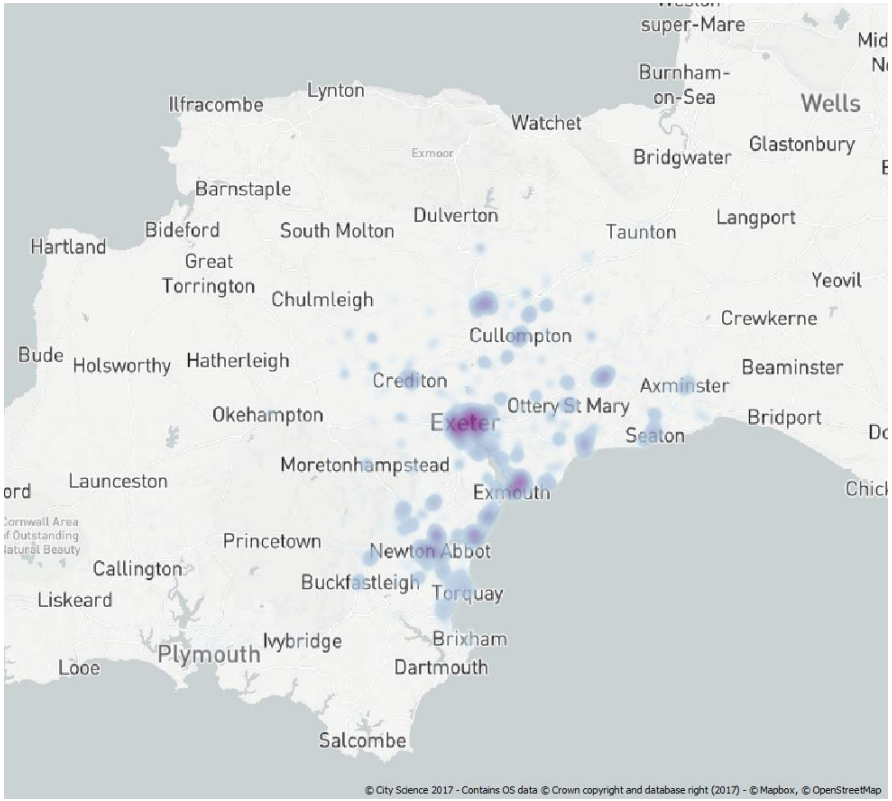

Figure 8: Distribution of origins (production zones) for trips ending in the Study Area (2001)

2.7.3 Figure 11 provides a plot of the production locations for all destinations within the Study Area in 2011. As can be seen, the 2011 spatial distribution is very similar to that for 2001.

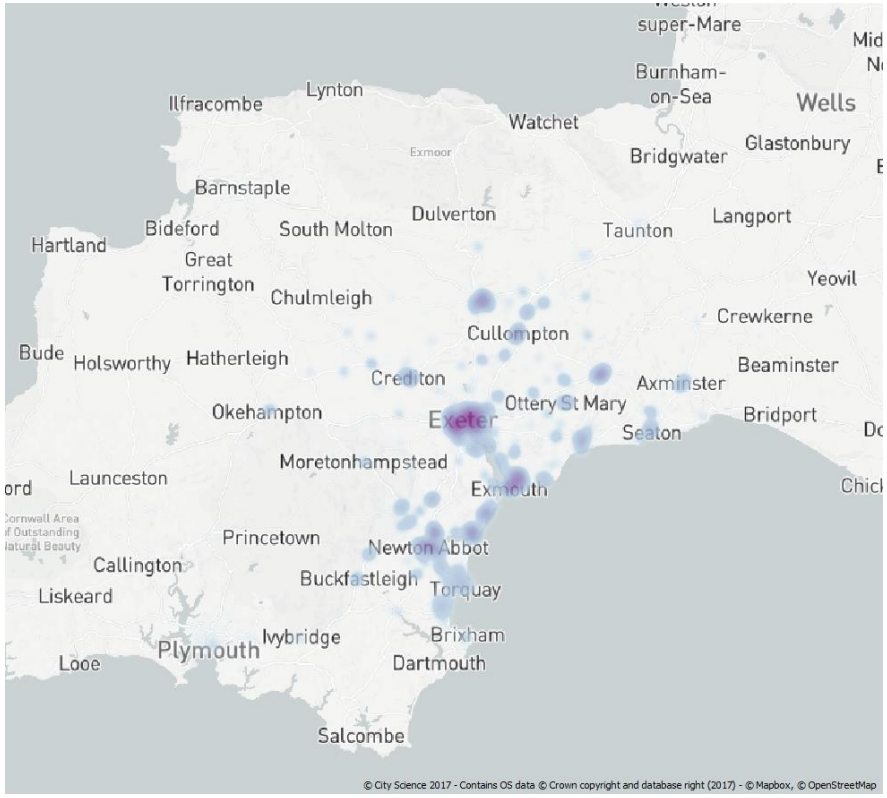

Figure 11: Distribution of production zones for trips with an attractor in the Study Area in 2011

3 Changes identified over time

3.1 Travel into Exeter

3.1.1 Travel to work demand for destinations in Exeter

The total number of daily trips with a destination in Exeter increased by 10.9% between the 2001 and 2011 census. This comprised a 26% increase in trips coming into Exeter from outside the city, while trips within the city fell -0.8%.

Mode	From Home	To Work	2001 Trips	(%)	2011 Trips	(%)	Absolute Change	% Change
Car	Exeter	Exeter	21,261	31.5%	17,363	23.2%	(3,898)	(-18.3%)
	Greater Exeter		19,888	29.5%	22,966	30.7%	3,078	15.5%
	Outside		5,917	8.8%	8,123	10.9%	2,206	37.3%
Non car	Exeter		16,713	24.8%	20,304	27.1%	3,591	21.5%
	Greater Exeter		2,830	4.2%	4,460	6.0%	1,630	57.6%
	Outside		849	1.3%	1,602	2.1%	753	88.7%
Total			**67,458**	**100.0%**	**74,818**	**100.0%**	**7,360**	**10.9%**

Table 7: Change between 2001 and 2011 for destinations in Exeter grouped by mode

3.1.2 Car vs. non-car trips for destinations in Exeter

Car journeys within Exeter fell by 18.3% between 2001 and 2011, while non-car journeys within Exeter grew by 21.5% over the same period, showing a positive evolution and implying a modal shift in transport choices for residents living and working within the city. Car-based trips into Exeter from Greater Exeter and beyond the Study Area however rose by 15.5% and 37.3% respectively. The overall effect was that car-based trips rose by 2.9% over the period. Non-car trips also showed strong growth rising 29.3% overall. The most considerable change related to non-car journeys coming from outside the Study Area where there was an 88.7% increase, albeit from a low base.

3.1.3 Exeter travel to work destination differences between 2001 and 2011

Figure 12 shows how travel to work destinations in and around Exeter have changed over the 10 year period, highlighting areas of job growth. The growth (shown in green) is mainly around the periphery of Exeter, with the largest growth being in areas around the Met Office, Exeter Business Park , Sowton Business Park, Pynes Hill and the University, with growth also seen around the RD&E hospital nearer to the city centre. In parallel with this growth around the periphery, there has been a reduction in travel to work for destinations in the historical centre.

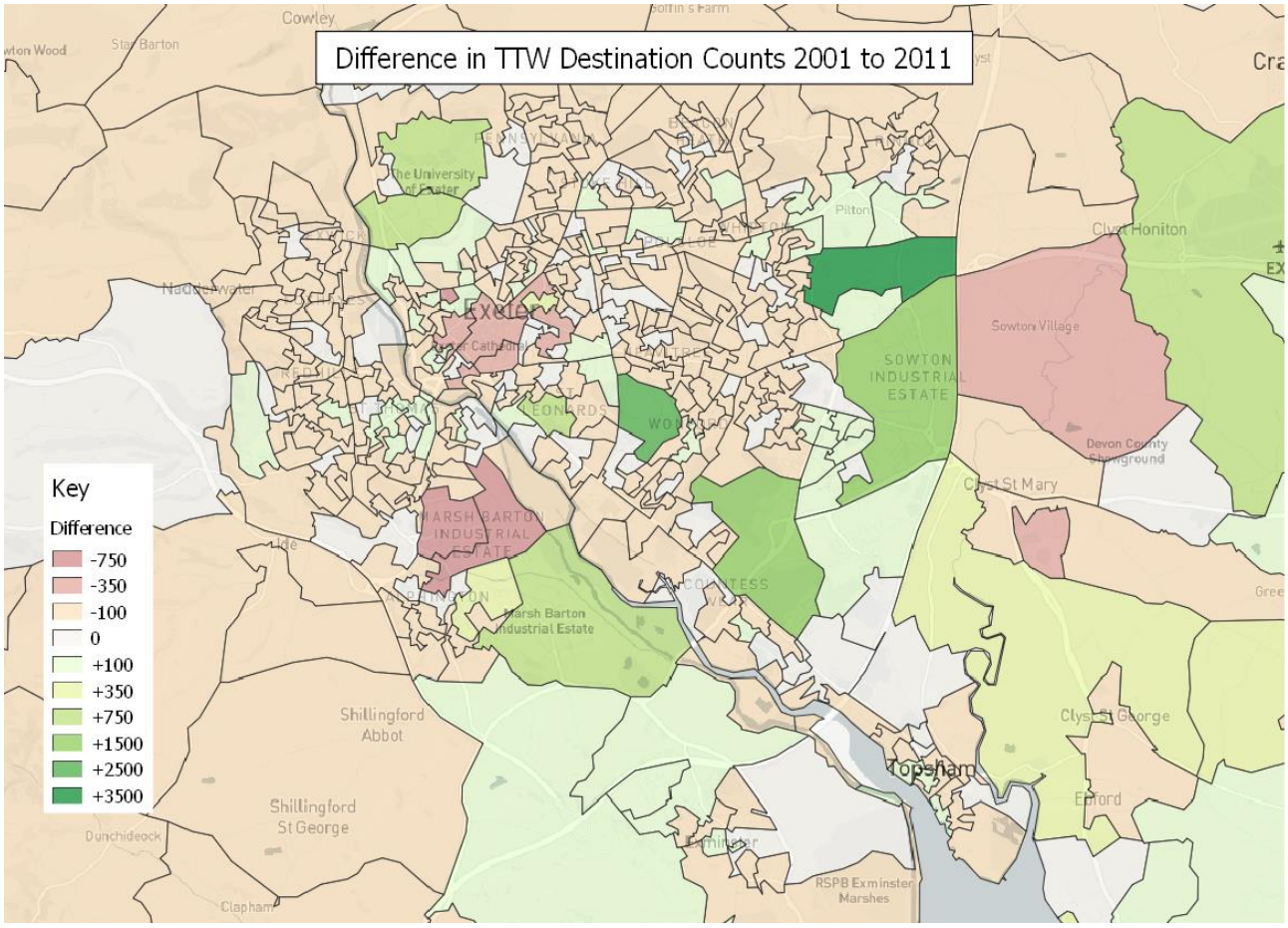

Figure 12: Heat map showing the differences in travel to work destination counts

3.2 Travel from Exeter and Greater Exeter

3.2.1 Travel to work demand from origins in Exeter

Total trip production for Exeter-based origins showed an increase of 10.3% between 2001 and 2011. However, since the population in Exeter also increased from 102,000 to 118,000, the trip production rate showed a decline. Trip rates per person fell from 0.51 trips/day/person to 0.49 trips/day/person.

From Home	To Work	Mode	2001 Trips	(%)	2011 Trips	(%)	Absolute Change	% Change
Exeter	Exeter	car	21,261	40.8	17,363	30.2	(3,898)	(-18.3)
	Greater Exeter	car	5,903	11.3	6,022	10.5	119	2.0
	Outside Greater Exeter	car	2,603	5.0	5,451	9.5	2,848	109.4
Exeter	Exeter	non-car	20,716	39.8	25,201	43.9	4,485	21.6
	Greater Exeter	non-car	909	1.7	1,513	2.6	604	66.4
	Outside Greater Exeter	non-car	678	1.3	1,877	3.3	1,199	176.8
Total			**52,070**	**100.0**	**57,427**	**100.0**	**5,357**	**10.3**

Table 8: Change in mode between 2001 and 2011 with Exeter origins

3.2.2 Travel to work demand from origins in Greater Exeter

Total trip production for Greater Exeter-based origins showed an increase of 12.9% between 2001 and 2011. The population in Greater Exeter increased from 314,000 to 334,000 during the same period meaning that trip rates per person increased from 0.45 trips/day/person to 0.48 trips/day/person.

From Home	To Work	Mode	2001 Trips	(%)	2011 Trips	(%)	Absolute Change	% Change
Greater Exeter	Exeter	car	19,888	14.1	22,966	14.5	3,078	15.5
	Greater Exeter	car	56,854	40.4	50,464	31.8	(6,390)	(-11.2)
	Outside Greater Exeter	car	16,901	12.0	29,346	18.5	12,445	73.6
Greater Exeter	Exeter	non-car	2,830	2.0	4,460	2.8	1,630	57.6
	Greater Exeter	non-car	42,193	30.0	47,048	29.6	4,855	11.5
	Outside Greater Exeter	non-car	2,082	1.5	4,589	2.9	2,507	120.4
Total			**140,748**	**100.0**	**158,873**	**100.0**	**18,125**	**12.9**

Table 9: Change in mode between 2001 and 2011 with Greater Exeter origins

3.3 Travel into Greater Exeter

3.3.1 Travel to work demand from destinations in Greater Exeter

The total number of daily trips ending in Greater Exeter declined by 3.1% between the 2001 and 2011 census. This overall reduction was due predominantly to a 9.6% decline in trips that begin and end within Greater Exeter. Trips from Exeter and outside of the Study Area rose by 10.6% and 28.9% respectively.

Mode	From Home	To Work	2001 Trips	(%)	2011 Trips	(%)	Absolute Change	% Change
Car	Exeter	Greater Exeter	5,903	6.0%	6,022	6.3%	119	2.0%
	Greater Exeter		56,854	57.5%	50,464	52.7%	(6,390)	(-11.2%)
	Outside		11,733	11.9%	14,503	15.1%	2,770	23.6%
Non car	Exeter		909	0.9%	1,513	1.6%	604	66.4%
	Greater Exeter		22,039	22.3%	20,865	21.8%	(1,174)	(-5.3%)
	Outside		1,383	1.4%	2,404	2.5%	1,021	73.8%
Total			98,821	100.0%	95,771	100.0%	(3,050)	(-3.1%)

Table 10: Change between 2001 and 2011 for destinations in Greater Exeter by mode

3.3.2 Car vs. non-car trips for destinations in Greater Exeter

Overall, car-based trips into Greater Exeter fell by 4.7% and non-car trips increased by 1.9%. The number of car-based trips fell most significantly (11.2%) for those trips starting and ending within Greater Exeter. This was modestly offset by increasing car trips (23.6%) from outside the study area. Although from a relatively low base, there was a notable percentage increase in non-car traffic from Exeter (66.4%) and outside the Study Area (73.8%).

3.3.3 It is important to note that whilst total trips fell, the trip production rate per person in Greater Exeter increased from 0.38 in 2001 to 0.40 in 2011 i.e. trip growth outpaced population growth.

This growth in trip rates becomes important in some of the models that extrapolate this trend into the future. Similarly, while the overall share of car trips produced fell, it can also be seen from the origin-based analysis that absolute car trips generated from Greater Exeter rose by 9.8%.

3.4 2016 Travel Demand

3.4.1 2016 Dataset Implications

As part of this analysis we have reviewed 2016 data collected through new techniques based on mobile network event data. The collection process and technology used is described in section 7.3. The significant methodological differences mean it is not appropriate to conduct direct comparisons between the data. However, differences in the data raise some important questions that that may bear further consideration.

3.4.2 Table 11 presents the work-based trips recorded in the CitiLogik data for each origin and destination pair. This table shows that the working trips recorded by CitiLogik are 35% lower than those recorded in the Census[5]. There may be a number of explanations for this difference, some of which may be methodological and others that may have important implications for commuting travel demand.

From Home	To Work	ONS JTW 2011	CitiLogik Work-based trips 2016	Difference	Difference (%)
Exeter	Exeter	42,564	23,395	(19,169)	-45%
Exeter	Greater Exeter	7,535	8,532	997	13%
Exeter	Outside	7,328	3,210	(4,118)	-56%
Greater Exeter	Exeter	27,426	8,723	(18,703)	-68%
Greater Exeter	Greater Exeter	71,329	82,675	11,346	16%
Greater Exeter	Outside	60,118	13,802	(46,316)	-77%
Outside	Exeter	9,725	3,258	(6,467)	-66%
Outside	Greater Exeter	16,907	13,831	(3,076)	-18%
Total		**242,932**	**157,426**	**(85,506)**	**-35%**

Table 11: Work-based trips recorded in the CitiLogik Data compared to ONS JTW

[5] Note this analysis is production-based and includes trips originally classified as "working from home".

3.4.3 Methodological differences could include:

- Home working trips accounted for differently in both datasets. In particular, census specifically captures these numbers as trips while mobile network data does not because no movement is actually recorded. In the census data trips classified as working from home comprise 11.5% of the Exeter-Exeter trips and 26.9% of the Greater Exeter – Greater Exeter trips. Adjusting for these trips would show overall trips at 26% lower than the Census JTW.
- There are known difficulties capturing short range trips using mobile network data techniques. Additional data is enabling more precise local measurements in these processes, but this improvement was not available at the time of the survey.
- Mobile network data is classified by inferred home and work positions based on algorithms to identify these types of regular journeys. However, where commuting habits are not regular, the process may classify these trips within a different group. The table below shows trips recorded as "Home-based-other" i.e. trips where a home location was inferred but a regular work trip was not. This is a large group of trips as it also includes all leisure or utility trips not related to a regular location. From this data alone it is impossible to disaggregate any additional trips that should legitimately be classified as work.

From Home	To Work	CitiLogik daily HBO trips 2016	CitiLogik Work-based trips 2016	% of work-based to other trips
Exeter	Exeter	158,708	23,395	15%
Exeter	Greater Exeter	33,050	8,532	26%
Exeter	Outside	19,348	3,210	17%
Greater Exeter	Exeter	33,749	8,723	26%
Greater Exeter	Greater Exeter	420,535	82,675	20%
Greater Exeter	Outside	72,938	13,802	19%
Outside	Exeter	19,549	3,258	17%
Outside	Greater Exeter	75,266	13,831	18%
Total		**833,143**	**157,426**	**19%**

Table 12: Home-based other trips recorded in the CitiLogik Data

3.4.4 Given the methodological differences it is impossible to say categorically where the difference in number lies. An additional real-world interpretation could be that the measurement of actual movement produces fewer daily trips than those inferred by the census, on the basis that commuters don't follow the same pattern every day. This can be seen when considering the impact of annual average effects e.g. commuters take 10% of the average working year as annual leave, with sick days accounting for additional non-travel days. These non-trips are not accounted for in census JTW and hence influence the comparison. Also an increase in days working from home may influence the number of journeys actually registered on the road compared to a survey response.

3.4.5 Reconciling these questions from existing datasets (including inferred trip rates from NTS) can lead to a wide range of adjustments. This section is included only to report on the potential conflicts between the datasets that also become apparent when comparing models to NTEM. We therefore list a set of factors that should be considered when converting from JTW to daily trips. It is important to note however, that these adjustments will not be fixed and will vary through the year based on seasonal and calendar factors.

3.4.6 The following factors could be considered to adjust census JTW figures production to a more appropriate daily outbound commuting trip estimate. The starting point is to assume 252 weekdays per year.

- FTE Adjustment: Overall workers in the South West work 4.3 days per week. This has the effect of a potential 14% reduction in outbound commuting trips depending on the structure of the working week.
- Adjustment for average holidays: 25/252 = 9.9% deduction
- Adjustment for average sick days: 5/252 = 2.0% deduction
- Working from home days (not recorded): 10/252 = 4.0%
- Out of office days (e.g. business trips): 5/252 = 2.0%
- Additional adjustments (e.g. maternity leave, jury service effects, etc)

Taking all these adjustments into consideration, it could be argued that a 32.5% reduction should be made to the unadjusted census JTW to achieve a suitable estimate for the trip rate observed.

3.5 Additional Considerations

3.5.1 Trends in observed LGV traffic

Trends in traffic from Light Goods Vehicles (LGVs) have been briefly reviewed as part of this report. Depending on the time of day this traffic demand persists, it is possible that increases here could have a material impact on peak hour demand. It is true that an increase in vehicle miles in Light Goods Vehicles has been observed in the national datasets.

One hypothesis that has been suggested is that LGV traffic is increasing due to changes in consumer purchasing habits, in particular, growing usage of online shopping. If this is the case then it may also be true that this traffic may decrease demand for other types of trips e.g. shopping trips. Time of day considerations will still be important when considering the potential impact of these trends on peak hour demand.

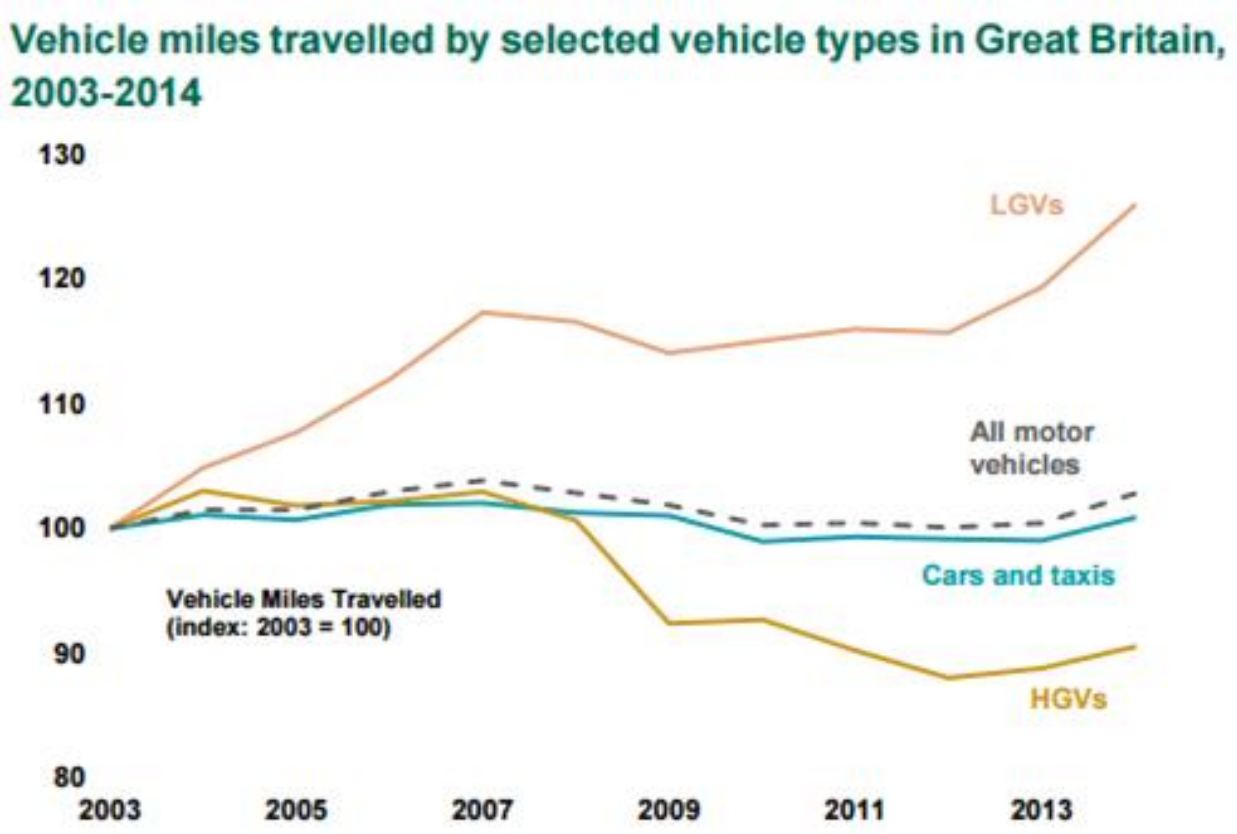

Figure 13: Vehicle miles travelled by selected vehicle types in Greater Britain, Source: Department for Transport [6]

3.5.2 We assessed observations of LGVs across Devon from AADF data, indexing observations in 2000 as the base year. In total, we observed data from 237 count points. 15 data sites are intermittent over the time period and so have been excluded. It should be noted that this analysis considers only the observations at the static count sites in the relevant years and while indicative, we have not estimated the total number of trips, nor vehicles, across the complete study area.

[6] Road Traffic Estimates: Great Britain 2014. Available at: https://www.paragonrouting.com/files/7114/4353/7956/annual-road-traffic-estimates-2014.pdf

3.5.3 Overall, observations of LGVs at count sites across the county have increased by 50.2% between the period 2000 to 2014. This increase is compared a base-line increase in traffic counts of 9.2%. In absolute terms the number of daily observations of light goods vehicles has increased by 175,000.

3.5.4 While the annual percentage change in LGV counts (3.9% increase per year) seems modest when viewed in isolation, once cumulative effects are taken into account the significance of the overall change is revealed. The average count site has observed a 58.2% increase in Light Goods Vehicles over the period, with the median count site observing a 53.9% change.

3.5.5 Figure 14 shows the linear change between 2000 and 2014 for each count point observation recorded in the AADF dataset for Devon. This shows the wide distribution of annual changes and highlights that certain count points have seen disproportionately large annual increases. Therefore, the impact on some parts of the network are higher than others.

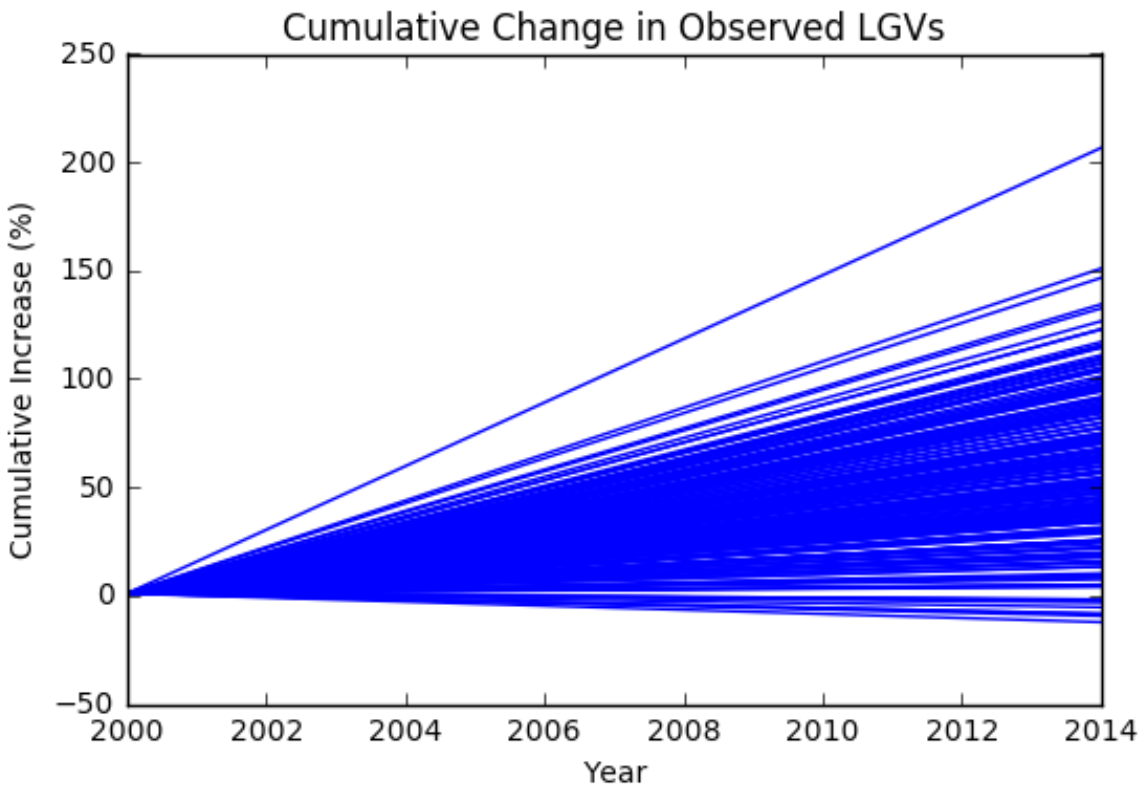

Figure 14: Cumulative Change in Observed LGV

3.5.6 As a result of the changes observed, the overall share of vehicles on the road which are LGVs can be seen to rise from 11.2% in 2000 to 15.4% in 2014. These trips are not captured in the census travel to work data as these are not commuting trips. Depending on time of travel, this increase may have an impact on peak hour travel. It is recommended that further work be undertaken to understand these trips and how their impact might be mitigated out to 2040.

4 Part 2: Time of Travel Analysis

4.1 National Travel Survey: Daily Trip Profiles

4.1.1 The National Travel Survey[7] is regarded as a definitive source on personal travel behaviour within the UK. Raw data were obtained from the Data Archive[8] on the 2002 to 2014 surveys. The underlying data enables specific custom queries to be performed. The data were first reconciled to the nationally published tables and then queried for South West Region and to distinguish between car and non-car commuters.

4.1.2 A range of extracts were considered based on data available for all commuter trips recorded in the surveys from 2010 to 2014 for England and Wales through to extracting data for car commuters living in urban areas in the South West of England for 2008 to 2014.

4.1.3 The data indicate only minor differences between the South West and National data. In the linked spreadsheets we have provided the option of taking a blended average between regional subset data and national data for these queries.

4.1.4 Overall there is minimal change in the observed peak trip commencement times between the 2001 and 2014 surveys at a National level. In both years ~17% of trips commence between 7am and 8am, while roughly 13% of trips commence between 5pm and 6pm. The largest change was within the 6am-7am time period where the share of trips increased from 8% of journeys to 9%.

4.1.5 Marginal difference in travel time preferences can also be observed in the national data between car commuters and non-car commuters. There is roughly a percentage point difference at both the beginning and end of the day with non-car commuters appearing slightly more likely to travel in the hour before the morning peak or the hour after the evening peak.

4.1.6 Comparing the national data to the sample from the South West shows only modest differences in the spread across the day. Again the difference for each hour is in the region of +/- one percentage point. The largest differences are between the 5am to 6am bucket and the 8am to 9am bucket with the national picture showing modestly more trips in the earlier period, offset by fewer trips in the later

[7] https://www.gov.uk/government/collections/national-travel-survey-statistics
[8] http://www.data-archive.ac.uk/

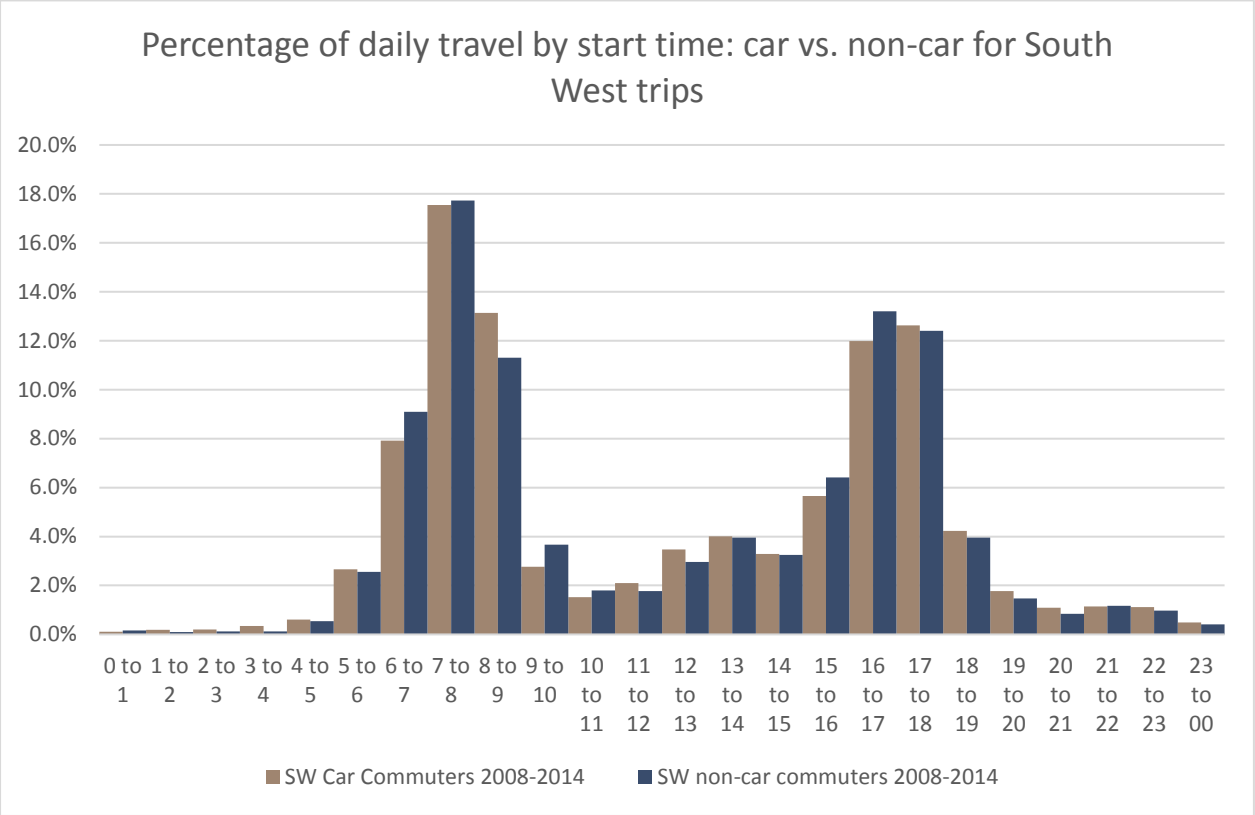

Figure 15: Percentage of daily travel by start time, car vs. non-car for South West trips

4.1.7 Data for the south west can also be split into car and non-car trips. Here a modestly higher percentage of non-car trips are made in the 6am to 7am period, 9am to 10am period and the 4pm to 5pm period. Lower percentages of non-car trips are observed in the 8am to 9am period – see Figure 15.

4.2 Application to Exeter Trips

4.2.1 Car Trips

The data for the distribution of trip departures has been processed according to the methodology outlined in section 7.4.1. This methodology is likely to provide a relative indication only, and not necessarily provide a robust predictor for observed trips due to the data and methodology limitations discussed. To improve the estimates, calibration and validation against radial car count data could be undertaken.

4.2.2 The estimated demand for car journeys is displayed in Table 13. The estimates would indicate that potentially 20,000 car trips with an origin or destination in Exeter start in the time period between 7am and 8am and a total of 45,000 car journeys commence between the hours of 6am and 9am.

4.2.3 It is estimated that the number of car trips has risen by 4.2% across the peak period of travel (7am-9am and 4pm-6pm) between 2001 and 2011. In absolute numbers, demand for car trips has increased by 1,156 in the morning peak and 1,500 in the evening peak.

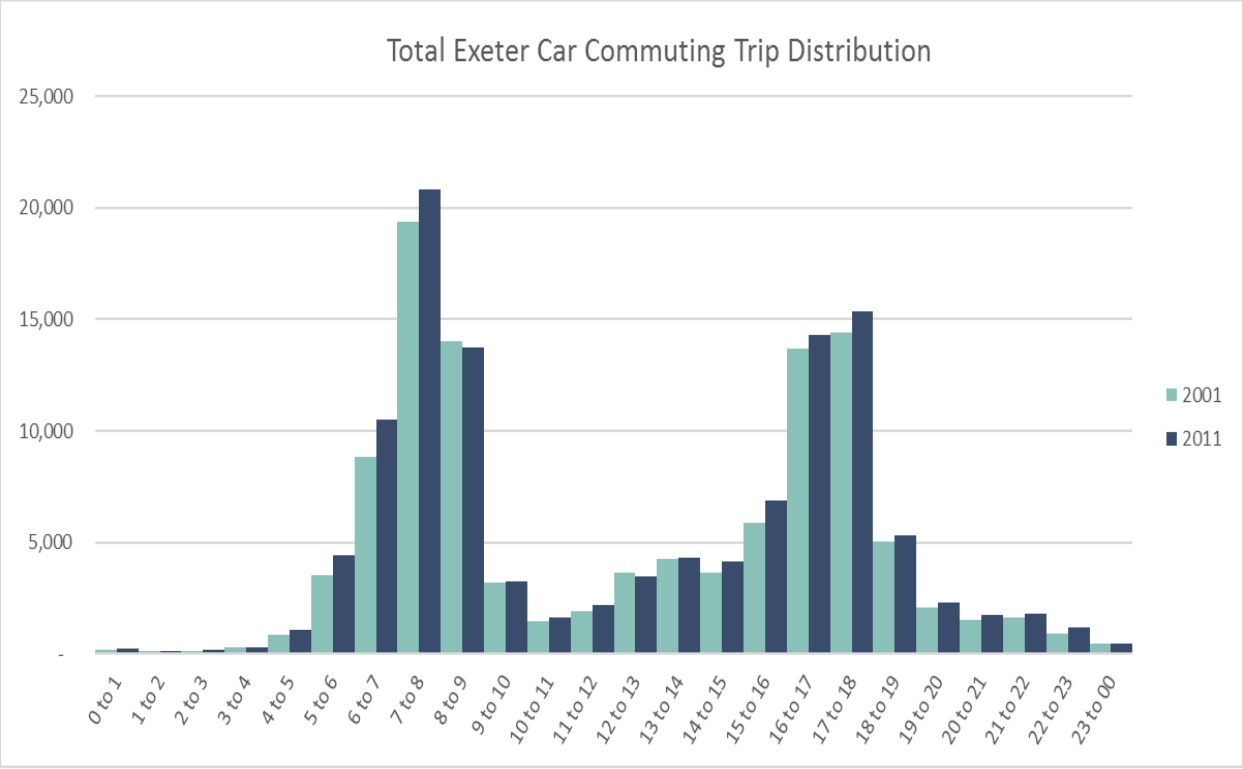

Figure 16: Total Exeter Car Commuting Trip Distribution

4.2.4 The following table gives a detailed hourly breakdown of the total Exeter hourly commuting trip distribution.

Time	Estimated Total Trips		% Change
	2001	2011	
0 to 1	204	219	7.62%
1 to 2	114	144	26.38%
2 to 3	129	168	30.42%
3 to 4	280	310	10.75%
4 to 5	869	1,058	21.79%
5 to 6	3,558	4,444	24.88%
6 to 7	8,846	10,478	18.45%
7 to 8	**19,362**	**20,823**	**7.55%**
8 to 9	14,037	13,732	(-2.17%)
9 to 10	3,206	3,254	1.49%
10 to 11	1,477	1,642	11.16%
11 to 12	1,893	2,198	16.11%
12 to 13	3,650	3,476	(-4.76%)
13 to 14	4,247	4,327	1.87%
14 to 15	3,663	4,136	12.92%
15 to 16	5,861	6,884	17.45%
16 to 17	13,688	14,311	4.55%
17 to 18	**14,427**	**15,362**	**6.48%**
18 to 19	5,037	5,333	5.88%
19 to 20	2,074	2,308	11.27%
20 to 21	1,527	1,773	16.10%
21 to 22	1,624	1,789	10.17%
22 to 23	921	1,198	30.15%
23 to 00	451	482	6.98%
Total	111,144	119,850	7.83%

Table 13: Hourly distribution of estimated total trips in Exeter

4.2.5 Non-car Trips

It is estimated that non-car trips originating or ending in Exeter have increased 33% between 2001 and 2011. The distribution of these trips across the day is shown below. It is seen that in the peak hour of 7am to 8am, almost 12,000 trips are made via non-car modes.

4.2.6 The absolute number of non-car trips during peak hours is also estimated to have increased more than that of car-based trips. In the period between 7am to 9am, the average demand for commuting trips is estimated to have increased by 4,900. In the evening peak (between 4pm and 6pm) the demand for trips has increased by 4,300.

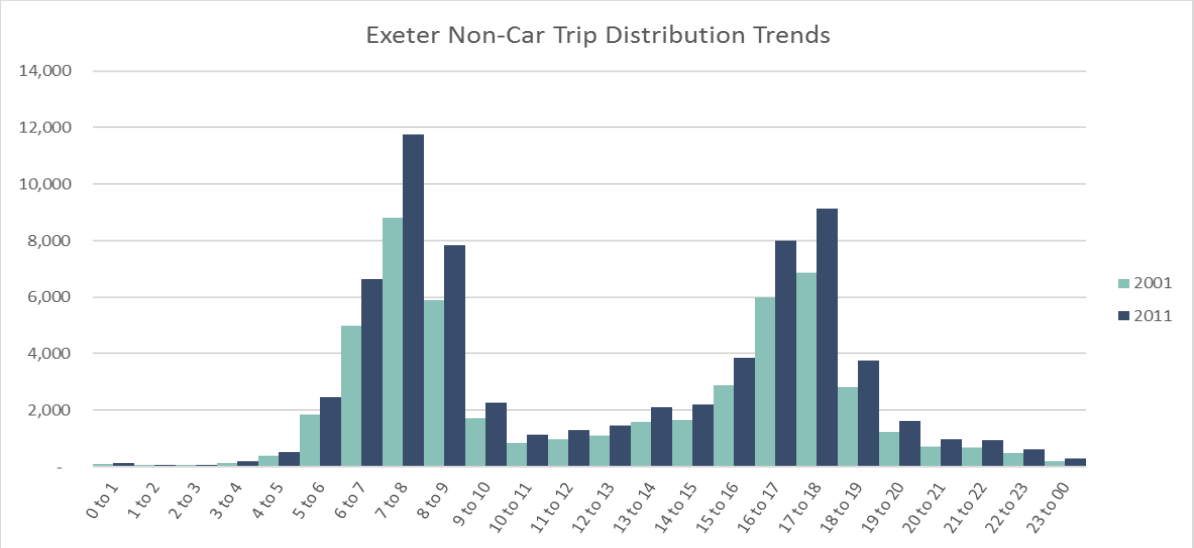

Figure 17: Exeter Non-Car Trip Distribution Trends

5 Part 3: Future Demand Scenarios and Model Considerations

5.1 Scenario background and development

5.1.1 Introduction

The aim of this section is to present a model that can provide a range of demand forecasts for trips in the study area over the time horizon of the GESP. The models are developed on the basis of relationships observed between trips, trip-rates and populations at an LSOA-level in the national census datasets. The models are then applied to the region based on estimates for population growth.

5.1.2 Different populations exhibit differing propensities to travel, and so the trip rate of a geographic area may reflect its demographic or socio-economic profile. To investigate potential drivers, a range of socioeconomic data were retrieved from ONS open census datasets and trip rates were plotted against these variables. The first part of this section presents the relationships observed in the national data.

5.1.3 Variables investigated included population, the median and mean age, levels of car ownership, economic activity status (percentage of unemployed, student or retired living in a given LSOA), and sectorial occupation, grouped into four classes (from nine ONS categories).

5.1.4 In the second part of this section, we present two models based on the data that provide a forecast of regional trip production into the future. In the first instance a simple trip-rate model is developed based on the relationships observed nationally through our analysis of commuting rates and population, and the population projections provided by DCC out to 2040. A more advanced model of travel demand is then proposed, taking account of the current and possible future economic and socio-demographic profiles of Exeter and Greater Exeter.

5.1.5 Scenarios are then developed to explore the extent to which additional variables may impact on trip growth to inform the range of possible outcomes. Both models have been provided in the accompanying Excel file so that relevant assumptions can be modified and their sensitivity explored. There are slight differences between the Python and Excel implementations resulting from the simpler implementation of the model in Excel.

5.1.6 Trip production forecasts are then recast and presented as attractor tables in a similar format to those used in Section 2 (From Home, To Work). These tables are disaggregated by car and non-car journeys.

5.2 Analysis of Influencing Factors

5.2.1 Population

The first factor considered is the total population of the region. In Figure 18below we plot the trip generation against the total population (left) and trip generation against population density (right) for each LSOA in England and Wales. The number of trips generated from an LSOA can be seen to vary relatively linearly with the population. By contrast, the relationship between population density and trip generation is much less clear. It is anticipated that this plays a greater role in trip attractors although this has not been explored in this study.

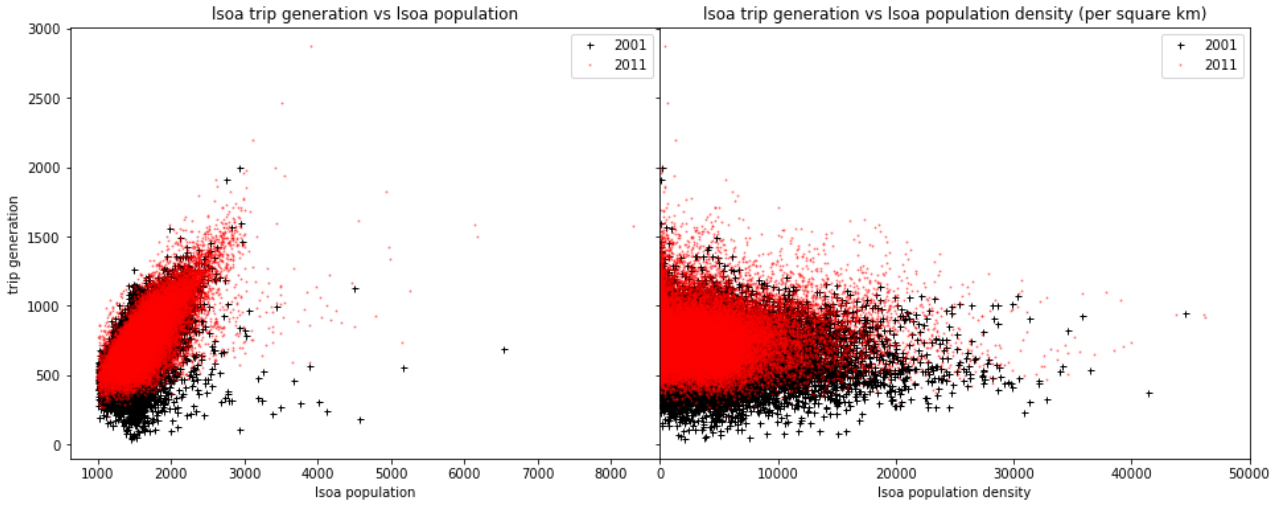

Figure 18: LSOA trip generation against population and population density in 2001 and 2011

5.2.2 Age structure

Figure 22 shows the relationship between trip rates and the age profile observed in an LSOA. Commuter trip rate peaks at ~ 0.6 trips per head of population, when the LSOA mean age is around 38 years old. In general, we observe that LSOAs with a mean age over 40, (comprising a larger number of retirees) or LSOAs with a younger population, below 25 (comprising pupils and students) generate fewer trips in the JTW dataset.

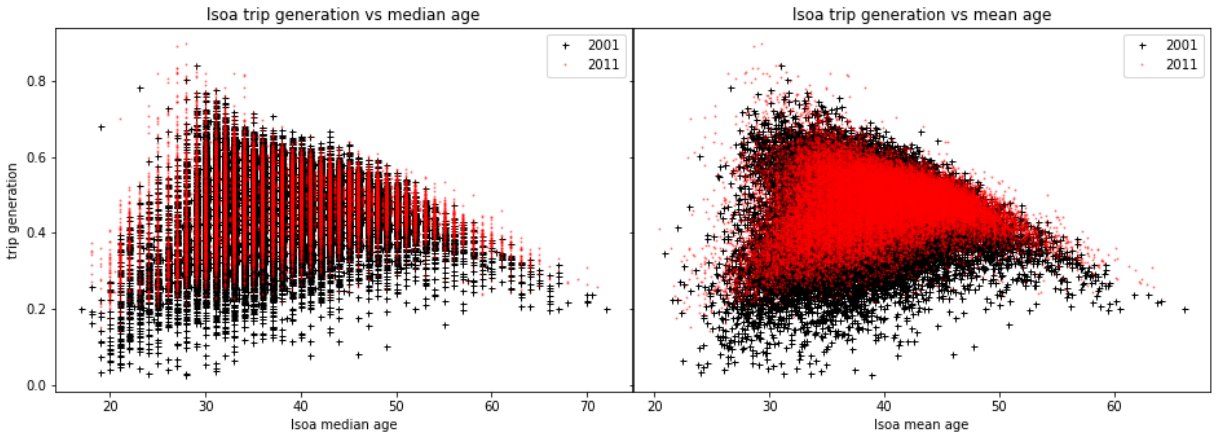

Figure 19: LSOA trip generation against LSOA mean and median age (2001 and 2011)

5.2.3 Economic Activity

Figure 20 explores the relationship between the percentages of unemployed adults and retirees within the LSOA population against trips generated. We observe that the higher the unemployment rate in an area, the lower the demand for trips. A similar trend is observed for the retired population percentage. The trend is less marked when considering the proportion of students within the population (Figure 21).

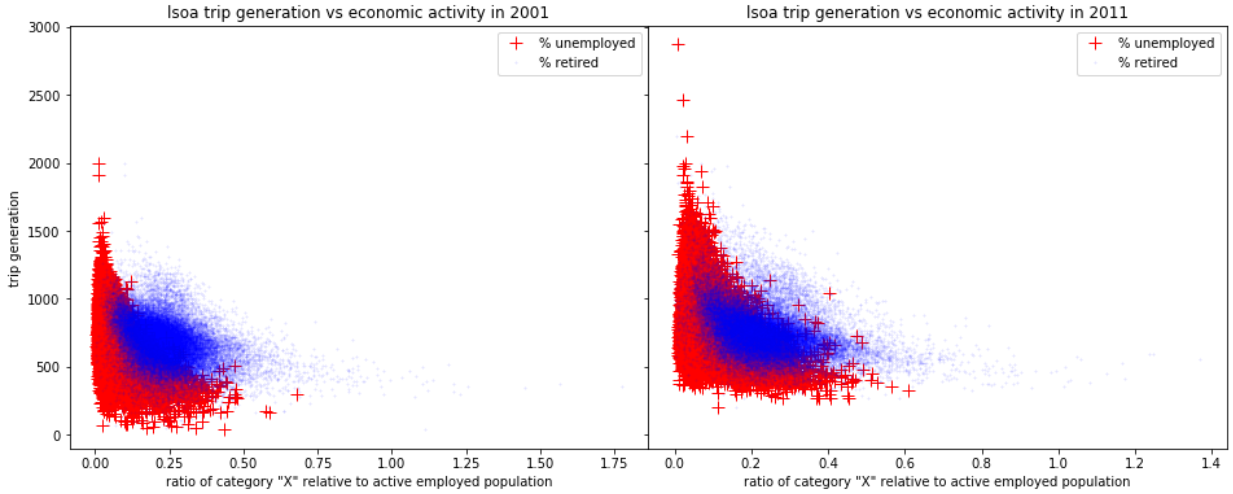

Figure 20: LSOA trip generation against economic activity for unemployed and retired population (2001 and 2011)

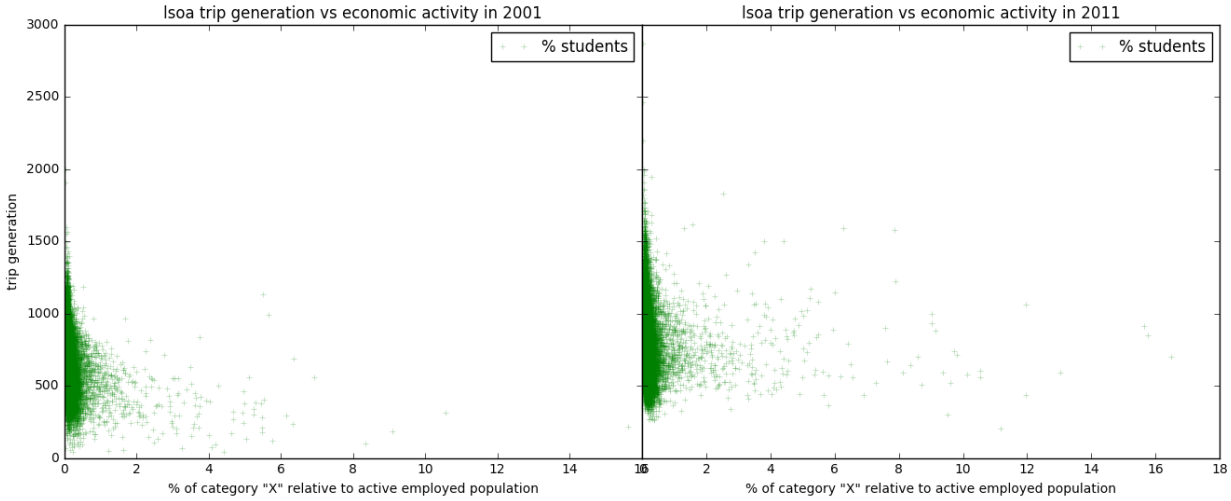

Figure 21: LSOA trip generation against economic activity for student population (2001 and 2011)

5.2.4 Socio-economic categories

ONS also provides data on socio-economic classification by LSOA broken into 9 categories of occupation type. We developed four categories to act as a proxy for these social classes from ONS occupational labels as described in section 7.5.4. Figure 22 shows that the trip rate from an LSOA decreases as the percentage of class 3 and class 4 inhabitants increases, while it increases as the percentage class 1 and class 2 inhabitants increases.

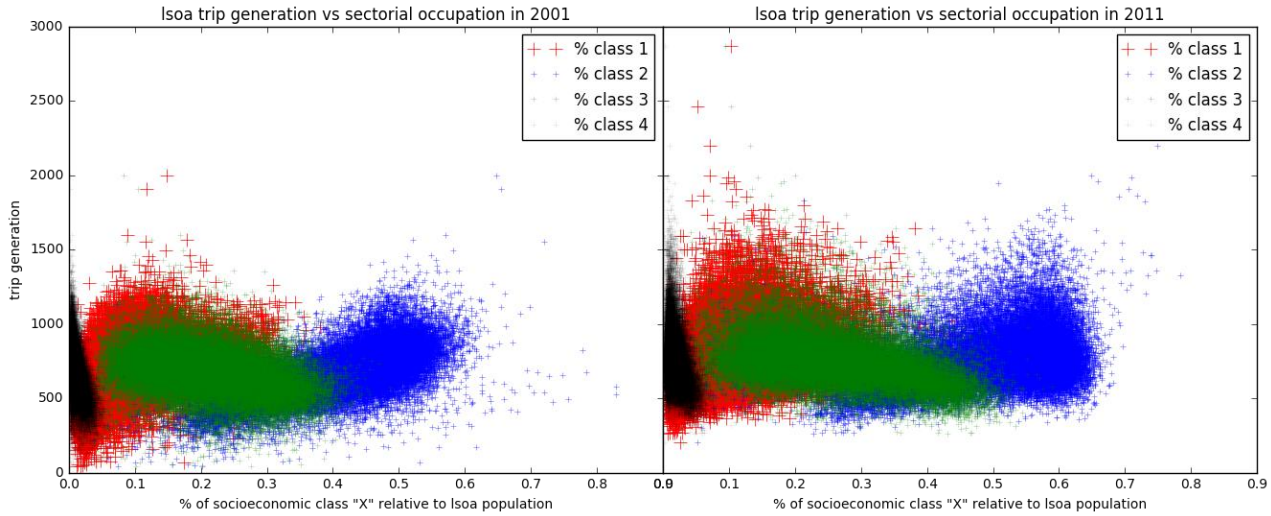

Figure 22: LSOA trip generation against sectorial occupation (2001 and 2011)

5.2.5 Car ownership

The final factor investigated is the level of car ownership within each LSOA. Figure 23 shows the relationship between the trip rate and the total number of cars available in each LSOA.

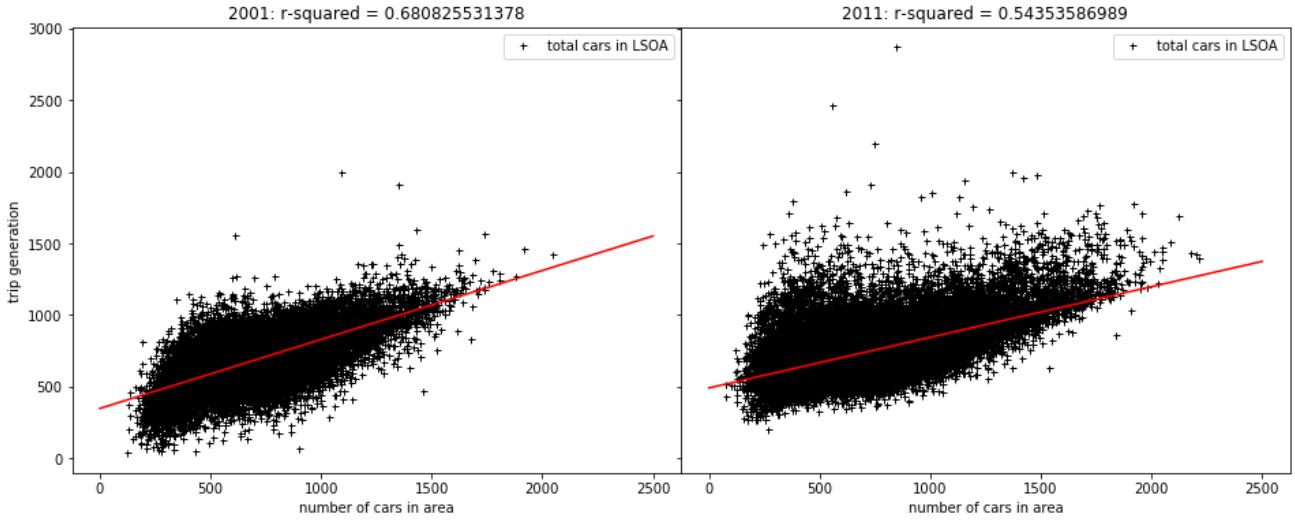

Figure 23: Relationship between trip generation and total number of cars

6 Part 4: Models and Results

6.1 Summary

6.1.1 Based on the multi-variable model and unadjusted census JTW data it is forecast that commuting trip production in the study area could reach 231,000 under the base-line scenario, growth of 25% from 2011 values, this compares to a population increase of 26.6%. The base-line trip-rate based model forecasts trip production in the study area between 232,000 and 234,000 depending upon which underlying population forecast is chosen.

6.1.2 This model results in commuting trips into and within Exeter of 96,000 in 2040 (an increase of 28% from 2011). In particular, 43,000 inbound commuting trips would be coming from outside of Exeter (a 15.7% increase), while 53,000 commuting trips would start and end within the city. Commuting trips to Greater Exeter would be 114,000, an increase of 19% from 2011. It is forecast that 74.5% (85,000) of these trips would be generated within Greater Exeter itself.

6.1.3 It is important to consider the adjustments that should be made for holidays, sick days, part-time employment and non-reported working from home. If such an adjustment is made, the model's predictions become comparable with NTEM in the base-year. It is important to note that seasonal effects (higher flu prevalence in winter, major national holiday periods) mean that any adjustment is not fixed throughout the year. In this section we present the unadjusted results, and a set of results that aligns to NTEM in the base-year. A discussion of possible adjustments is included in section 3.4.6 which could result in adjusted figures being lower by ~30% depending on which assumptions are adopted.

6.1.4 Two models are presented in both unadjusted and adjusted form. Unadjusted figures are presented in order to compare with the census JTW data presented throughout the remainder of this document. Adjusted forecasts are presented in order to be more comparable with NTEM. In each case, scenarios were developed to explore the sensitivity of travel demand to a range of factors. For each model, 4 scenarios were plotted to show the range of possible outcomes.

6.2 Model 1: Trip-rate - population model

6.2.1 Initially a first-order population-based forecast was developed based on the trip demand observed in the 2001 and 2011 census. Trip rates were developed for Total Trips, Car Driver + Car Passenger and Car Driver only categories from the census. Trip rates were calculated by LAD based on:

$$\alpha = \frac{Trips}{population}$$

6.2.2 In order to output a range of forecasts the following scenarios were developed

- **Scenario 1 ('Plateau Scenario')**: Trip rates are assumed to remain constant based on 2011 values.
- **Scenario 2 ('Trend Scenario'):** Trip rates were varied linearly according to the rate of change (slope) observed between 2001 to 2011.
- **Scenario 3 ('Maximum Trip Rate Scenario'):** The trip rate is assumed as the maximum value observed in 2001 or 2011.
- **Scenario 4 ('Minimum Trip Rate Scenario')**: The trip rate is assumed as the minimum value observed in 2001 or 2011.

6.2.3 A further custom scenario is available in the Excel model that allows the user to specify expected trip rates for each of the forecast years.

6.2.4 Trip rates are then multiplied by the population projections provided. The model has also been used against population projections sourced from ONS. Figure 25 shows the results of the unadjusted model for outbound commuting trips while Figure 26 shows the results with the inclusion of adjustments for holiday, sickness, etc. It can be seen in Figure 26 that, even if forecasts are aligned to NTEM in the base-year, projections in this model see demand increasing much faster under all scenarios.

Production Zone	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	59,773	67,139	73,521
Greater Exeter Trips	120,594	132,690	143,272	152,316	157,862
Study Area Total	**168,661**	**185,220**	**203,045**	**219,455**	**231,383**

Table 14: Base-case (Plateau Scenario) home to work trip production by origin zone

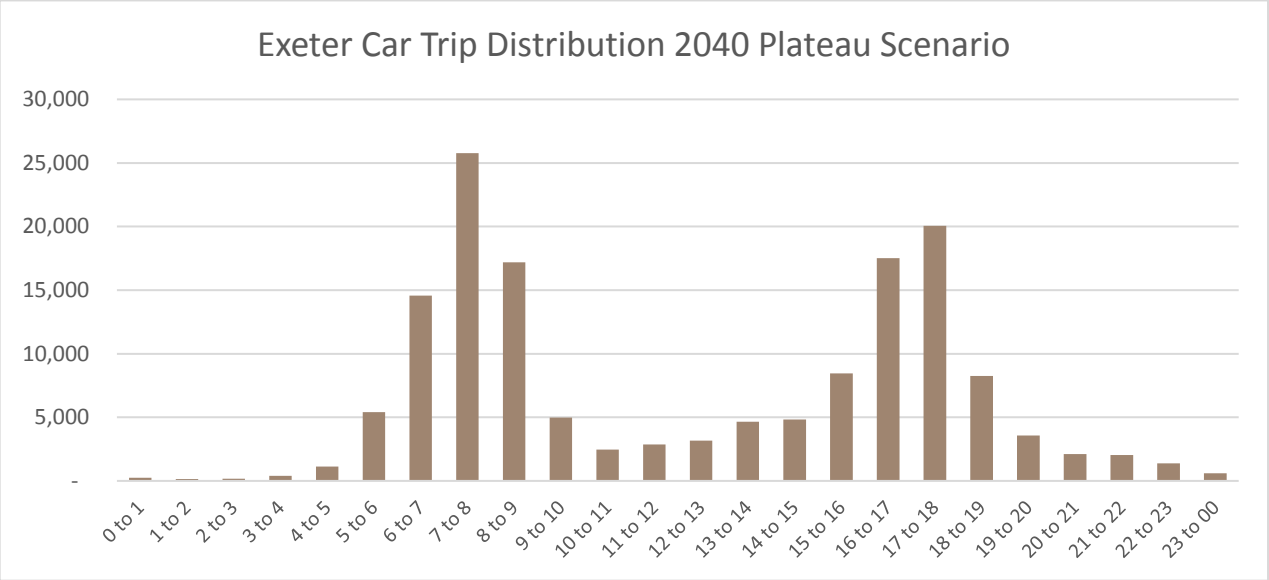

Figure 24: Exeter car trip distribution 2040 plateau scenario

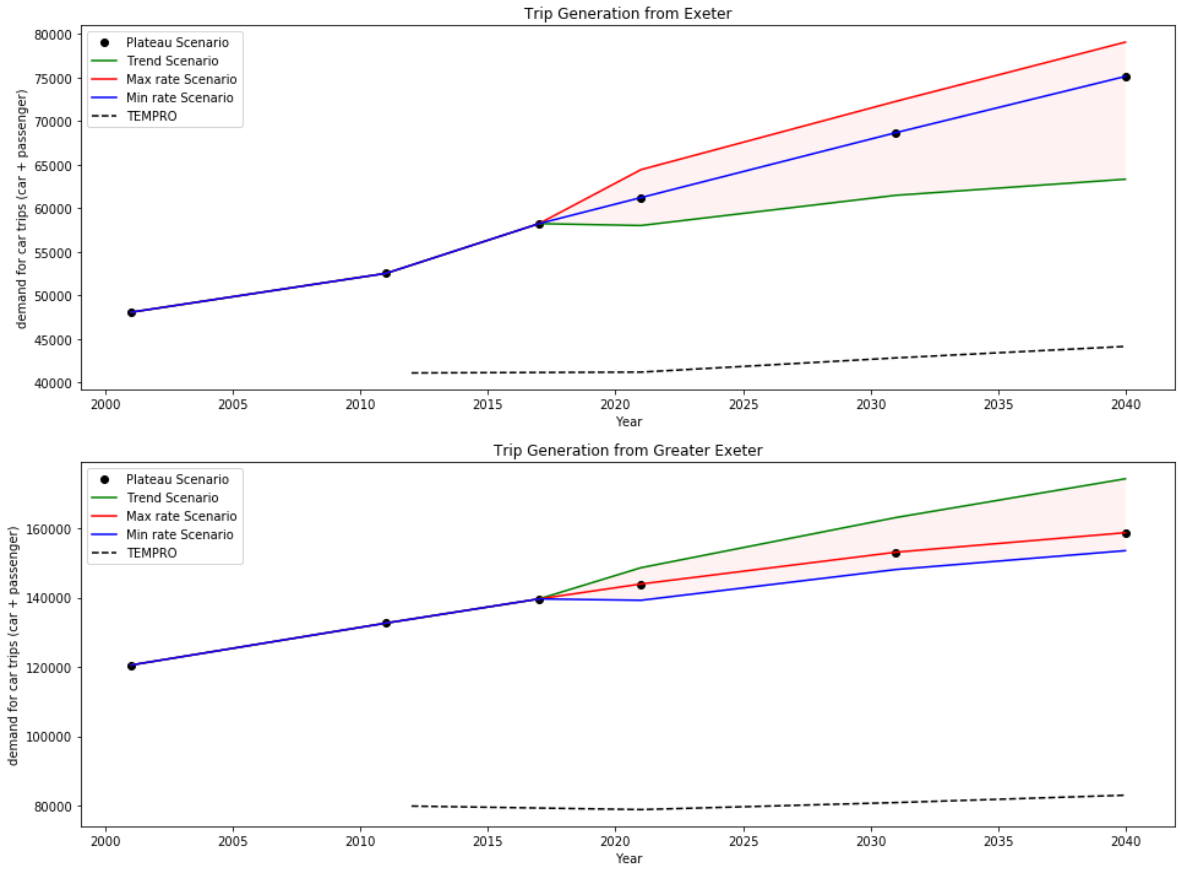

Figure 25: 2040 Model 1 Unadjusted forecast scenario fan chart (all outbound commuting trips)

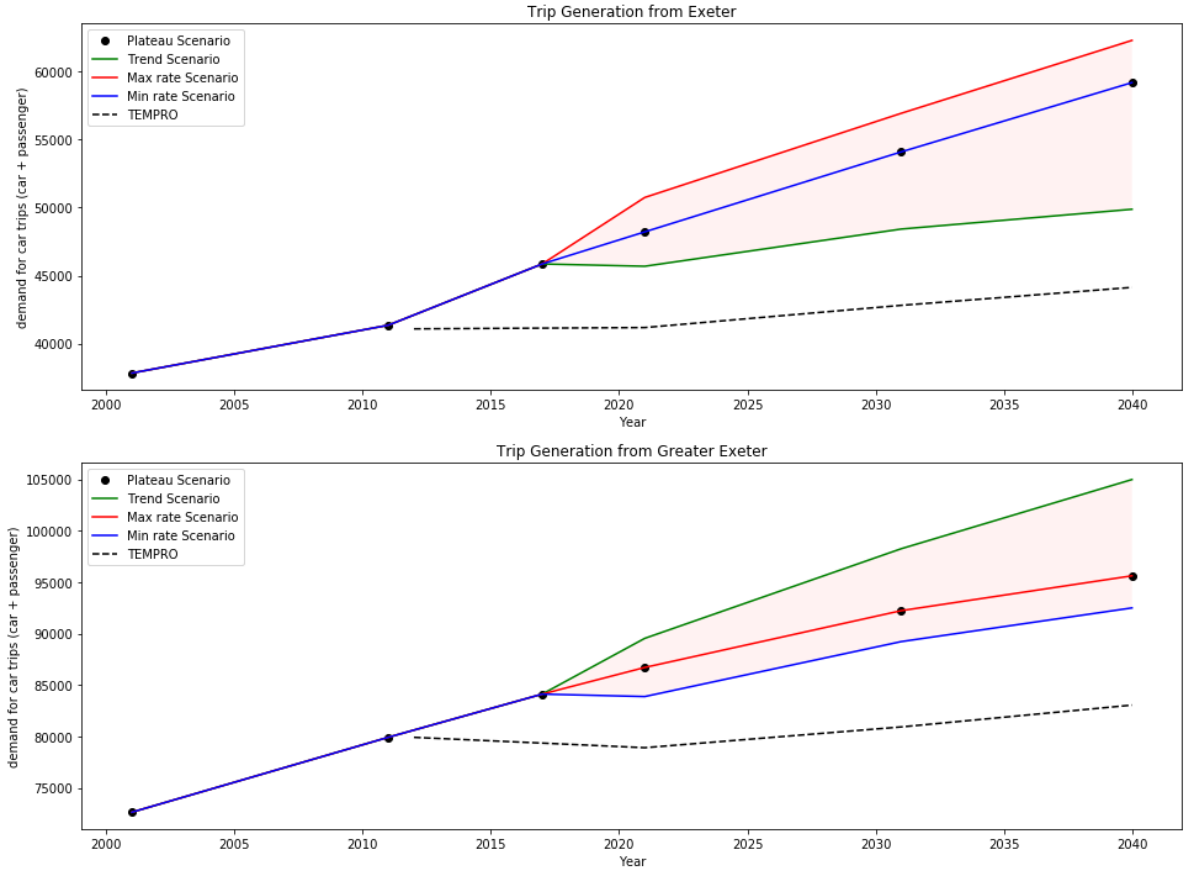

Figure 26: 2040 Model 1 Adjusted forecast scenario fan chart (all outbound commuting trips)

6.3 Model 2: Multivariable Regression Model

6.3.1 In order to provide a model that takes into account a wider range of variables, a multivariable model has been constructed. Eight variables were selected from the set of data explored in section 5 based on the strength of relationship observed. The model developed is of the form:

$$trip_{demand} = \alpha_0 + \alpha_1 * population + \alpha_2 * class + \alpha_3 * retired + \alpha_4 * student + \alpha_5 * unemployed + \alpha_6 * CarOwnership + \alpha_7 * (38 - MeanAge)^2 + \alpha_8 * PopulationDensity$$

6.3.2 The model was then developed in python based on data from all LSOAs in England and Wales. The regression coefficients obtained are shown in the Ordinary Least Square (OLS) Regression Results table below. It can be seen that the model has an overall R-squared coefficient of 0.795.

OLS Regression Results

Dep. Variable:	trips	R-squared:	0.795
Model:	OLS	Adj. R-squared:	0.795
Method:	Least Squares	F-statistic:	3.305e+04
Date:	Thu, 04 May 2017	Prob (F-statistic):	0.00
Time:	16:52:23	Log-Likelihood:	-3.9707e+05
No. Observations:	68269	AIC:	7.942e+05
Df Residuals:	68260	BIC:	7.942e+05
Df Model:	8		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-13.8319	3.462	-3.996	0.000	-20.617	-7.047
population	0.4613	0.001	371.537	0.000	0.459	0.464
unemployed	-905.3737	9.358	-96.750	0.000	-923.715	-887.032
retired	-564.5870	3.806	-148.328	0.000	-572.047	-557.127
student	-90.2041	1.013	-89.024	0.000	-92.190	-88.218
area_cars	403.7705	3.876	104.167	0.000	396.173	411.368
density_per_km2	0.0070	0.000	63.054	0.000	0.007	0.007
class_3	42.7361	4.208	10.156	0.000	34.488	50.984
mean_age	-0.1165	0.009	-12.275	0.000	-0.135	-0.098

Omnibus:	22740.877	Durbin-Watson:	1.446
Prob(Omnibus):	0.000	Jarque-Bera (JB):	751043.972
Skew:	-0.963	Prob(JB):	0.00
Kurtosis:	19.134	Cond. No.	1.80e+05

Table 15: OLS Regression Results

6.3.3 Because the variables have different orders of magnitude with some expressed as percentages, interpretation of the parameters may not be immediate. However, it is clear that the driving factors highlighted in section 5 are confirmed. The main factors leading to an increase in trip demand within the model are the area's population, car ownership per head of population and the percentage of 'class 3' workers.

6.3.4 Factors leading to a decrease in trip demand are the proportion of unemployed adults, the proportion of retirees and students. A simplified version of the model has been implemented in Excel where the user can manipulate variable assumptions for each of the forecast years.

6.3.5 It should be noted that while flexibility has been accommodated, no additional adjustment has been made in Model 2 to ensure that "extreme values" give the expected results in all cases. For example, setting car ownership to zero will not result in no car trips. This is due to the additive behaviour of the model (which can be observed in the unlocked version of the Excel file).

6.3.6 As with Model 1, several scenarios were developed to produce a range of possible trajectories for trip production from Exeter and Greater Exeter. Since Model 2 allows more flexibility with a wider number of variables we are able to build in a greater degree of "what if" analysis in the scenarios observed. The impact of technology and effects of an aging population are largely unknown. Literature is inconclusive regarding the possible effects of, say, greater vehicle autonomy over the time horizon with some authors believing propensity to travel will increase and other seeing lower car ownership, and more optimized networks becoming the dominant trend. Model 2 allows us to crudely begin exploring this range of possible futures.

6.3.7 **Scenario 1 (Plateau):** This is the simplest forecast. Here, all variables except population and population density are locked to their 2011 levels. Since the majority of features are expressed as percentages no additional scaling is applied.

6.3.8 **Scenario 2 (Travel Propensity Increase):** In this scenario, it is assumed that the introduction of autonomous vehicles leads to increased mobility within the retired and working age demographic that would ordinarily travel less or work from home. In this scenario, the observed decrease in travel demand as the mean age of the LSOA rises is removed. This is done by arbitrarily setting the average age to 38 and then removing the currently observed retired population effects. That is not to say that the average age will be 38 - rather that the future population will behave more like today's 38 year olds.

6.3.9 **Scenario 3 (Falling trip rates):** Scenario 3 aims to explore the impact of falling trip rates due to technology changes. In the model this is implemented simply by setting the car ownership variable to a third of its 2011 value. Based on the way the model is currently implemented this has the effect of dampening trip demand by ~9,000 in Exeter and 30,000 in Greater Exeter. As discussed previously, extreme values are not catered for by the current model implementation and so the adjustment to car trips should merely be viewed as mechanism to explore a low scenario, rather than an accurate predictor of car trips.

6.3.10 **Scenario 4 (Current Trends):** In this scenario, variables are allowed to change based on those observed in the data between 2001 and 2011. Effectively this means we apply a linear relationship to each variable at an LSOA level. Results are then run by LSOA and aggregated. In the Excel implementation, trends are projected at a zone-level only.

6.4 Results: Base-case scenario (Plateau Scenario)

6.4.1 The results of Model 2 and the scenarios developed are shown in the fan charts below (Figure 27 and Figure 28). This shows the production of outbound commuting trips for all scenarios and the range of possibilities (shaded pink) that lay between them. Unadjusted outputs for the base-case Plateau Scenario are shown in Figure 16.

6.4.2 It can be seen that under the unadjusted base-case (Plateau Scenario) outbound commuting trip generation in the study area grows to 231,000 from 185,000 today. This is split between 73,000 trips generated by Exeter and 158,000 trips generated by Greater Exeter. While not comparable, the fan chart also shows the NTEM / TEMPRO predictions for completeness. These lie much lower than the census based forecast due to the effect of holiday / sick day and part-time work etc.

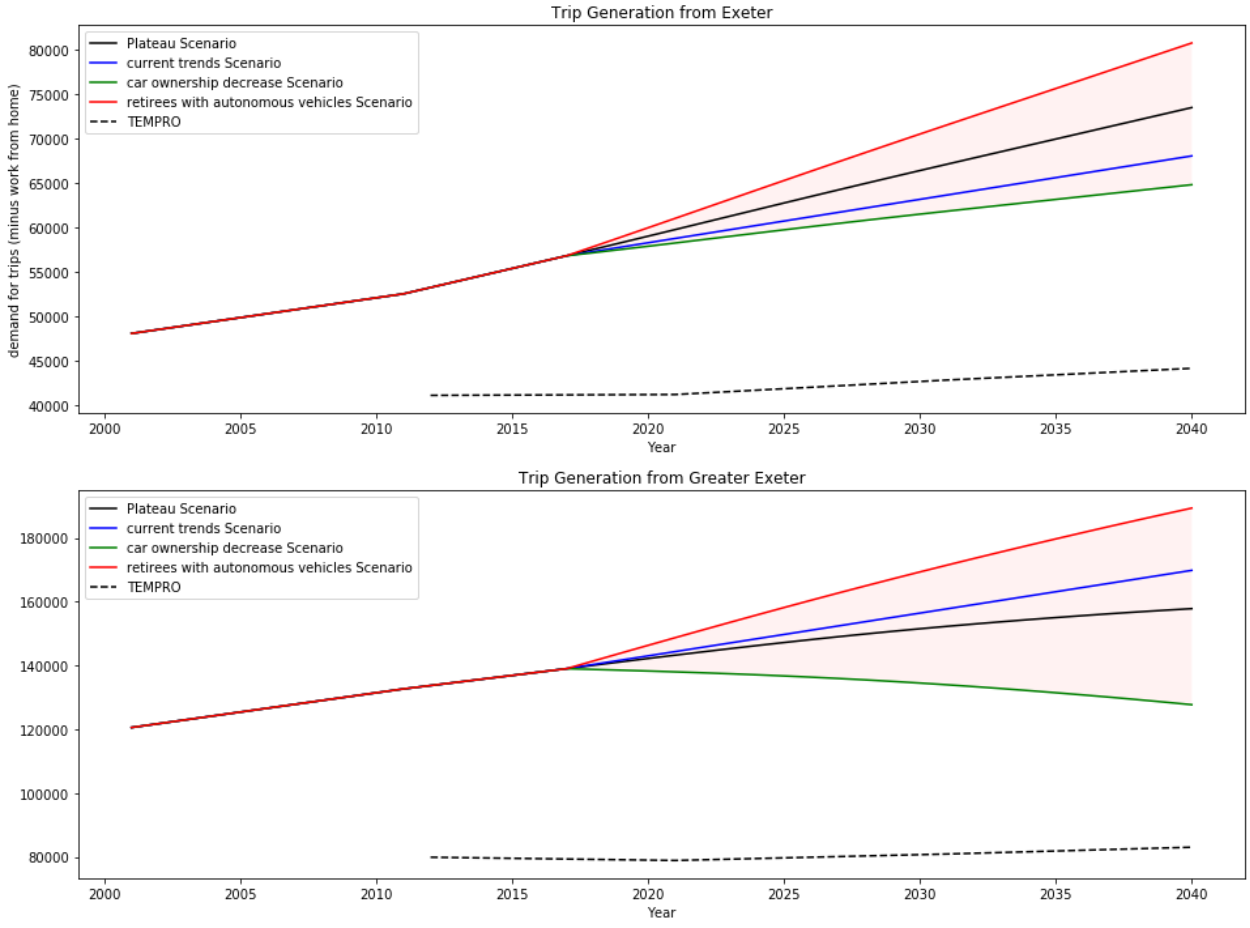

Figure 27: 2040 Model 2 unadjusted forecast scenario fan chart (all outbound commuting trips)

Production Zone	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	59,773	67,139	73,521
Greater Exeter Trips	120,594	132,690	143,272	152,316	157,862
Study Area Total	**168,8661**	**185,220**	**203,045**	**219,455**	**231,383**

Table 16: Base-case (Plateau Scenario) home to work trip production by origin zone

6.4.3 Figure 28 shows the results of Model 2 after accounting for these adjustments and reconciling with NTEM in the base year. Here it can be seen that there is a better fit, but growth in Model 2 still outpaces that forecast by NTEM in all but the car-ownership decline scenario. NTEM documentation notes this trend but the model itself does not forecast any decline in car-ownership.

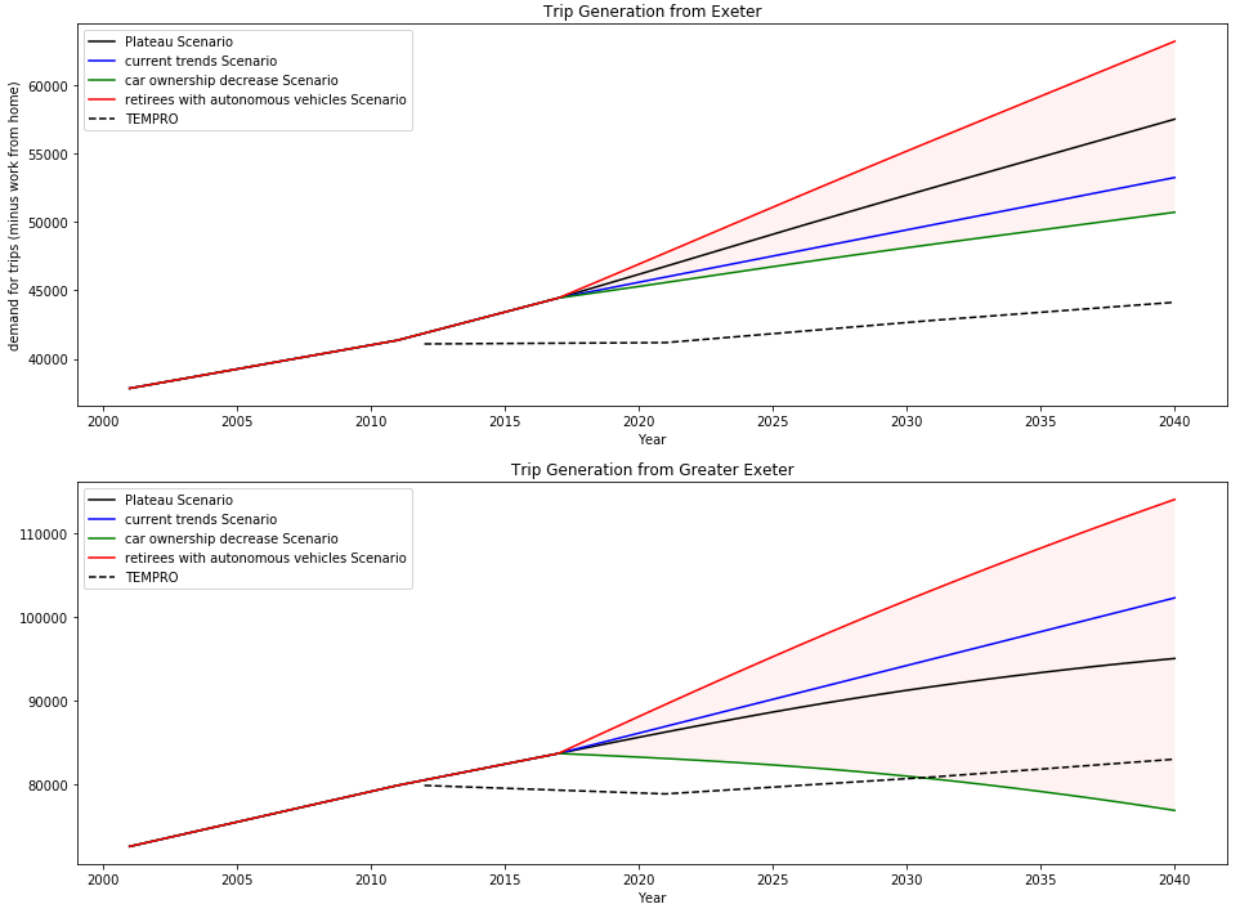

Figure 28: 2040 Model 2 Adjusted forecast scenario fan chart (all outbound commuting trips)

6.4.4 The Plateau Scenario translates into travel into and within Exeter increasing (28.3%) to 96,000 inbound commuting trips by 2040. This comprises 53,000 journeys starting and ending within the city and 43,000 trips coming from outside the city.

From Home	To Work	Mode	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Exeter	Car	21,261	17,363	19,757	22,192	24,301
		Non-Car	16,713	20,304	23,104	25,951	28,417
Greater Exeter		Car	19,888	22,966	24,798	26,363	27,323
		Non-Car	2,830	4,460	4,816	5,120	5,306
Outside		Car	5,917	8,123	7,895	8,391	8,887
		Non-Car	849	1,602	1,557	1,655	1,753
Total			**67,458**	**74,818**	**81,926**	**89,671**	**95,988**

Table 17: Forecast travel demand into Exeter under the Plateau Scenario

6.4.5 For travel into Greater Exeter this same scenario translates into a forecast 114,000 inbound commuting trips (an increase of 19.0% from 2011). 85,000 of these trips are anticipated to be generated in the region itself with 18,000 originating outside the study area and 11,000 coming out from Exeter city.

From Home	To Work	Mode	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Greater Exeter	Car	5,903	6,022	6,852	7,697	8,428
		Non-Car	909	1,513	1,722	1,934	2,118
Greater Exeter		Car	56,854	50,464	54,488	57,928	60,037
		Non-Car	22,039	20,865	22,529	23,951	24,823
Outside		Car	11,733	14,503	14,097	14,982	15,868
		Non-Car	1,383	2,404	2,337	2,483	2,630
Total			**98,821**	**95,771**	**102,025**	**108,975**	**113,904**

Table 18: Forecast travel demand into Greater Exeter under the Plateau Scenario

6.4.6 The adjusted forecast outbound car (car driver plus car passenger) commuting trips under this scenario are presented in the fan charts below (Figure 29), again alongside the equivalent NTEM forecasts. It can be seen in both these fan charts that NTEM sits at the lower end of the forecast range for outbound commuting trip production in Exeter and Greater Exeter based on the population inputs provided.

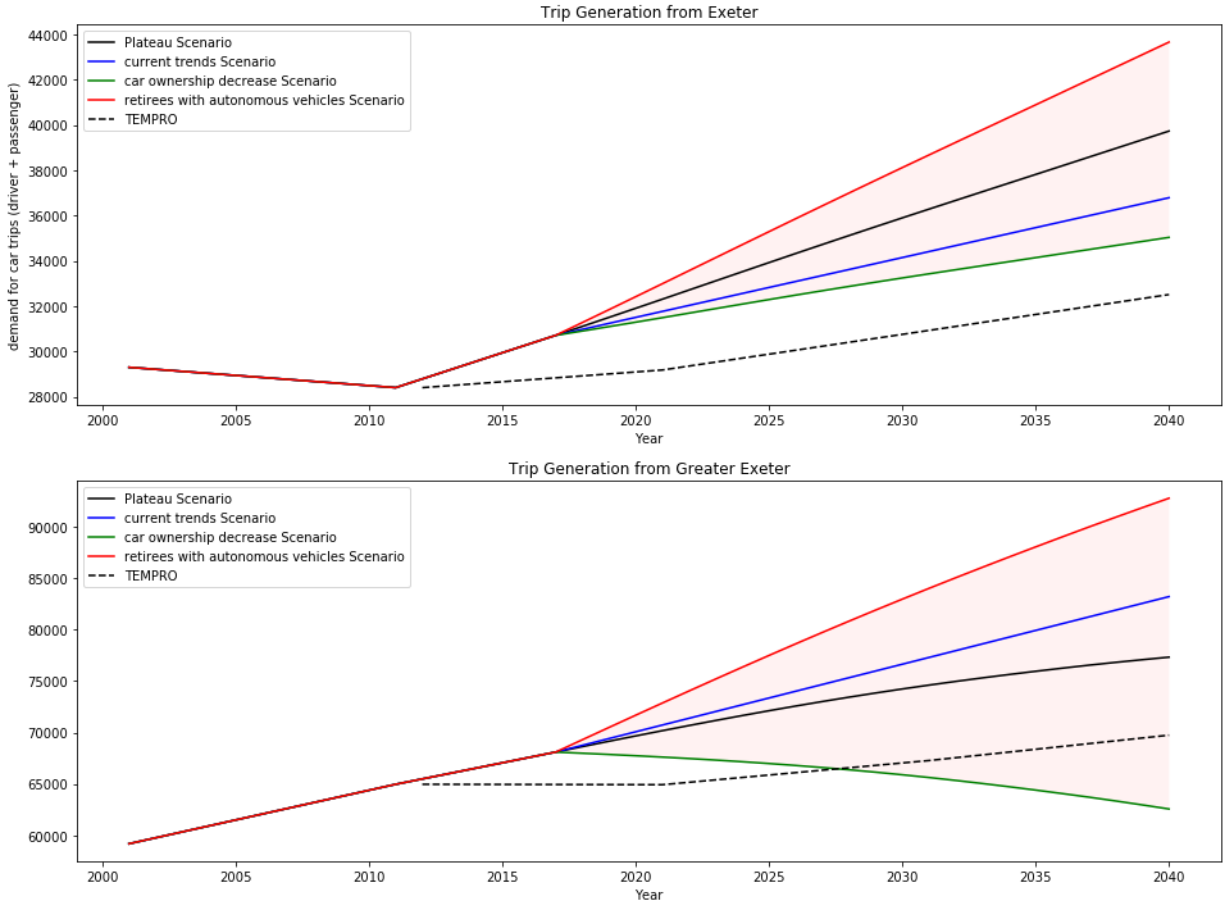

Figure 29: 2040 Model 2 Adjusted forecast scenario fan chart (driver + passengers)

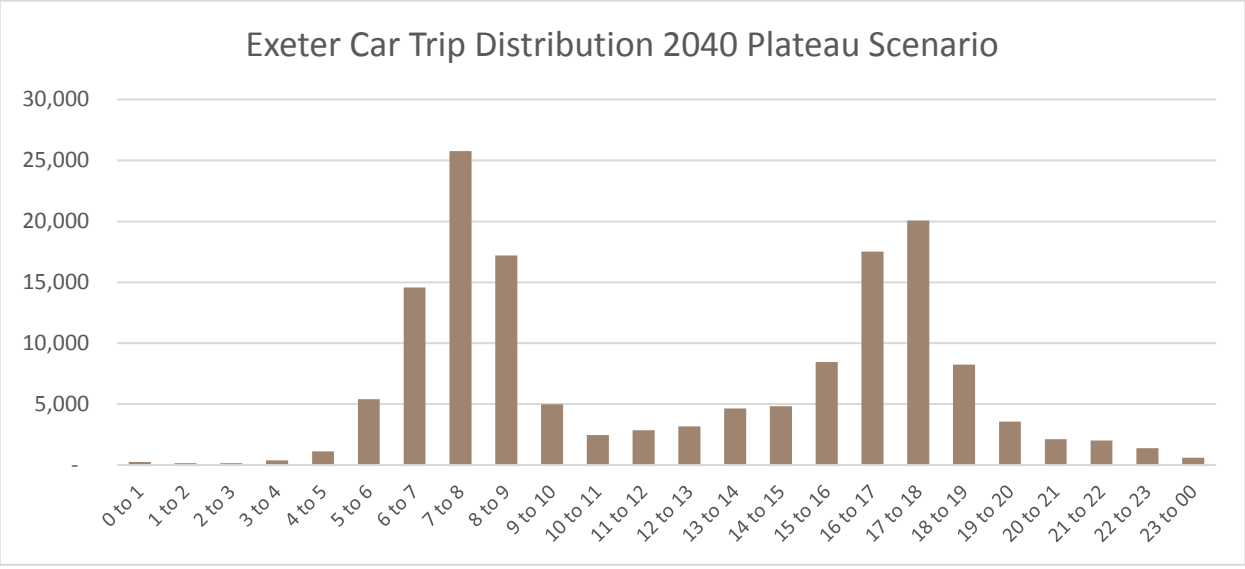

Figure 30: Exeter car trip distribution 2040 Plateau scenario

6.5 Results: Additional Scenarios

6.5.1 While the high (Scenario 2), low (Scenario 3) and trend (Scenario 4) scenarios are implicitly considered in the fan charts, a brief overview of the results is presented in the following sections. The additional scenarios, in particular Scenario 2 and 3, are consciously at the extremes to test the sensitivity to a range of possible outcomes or trends over such a long time horizon. The previously mentioned caveats regarding the performance of the model in cases that utilize extreme values apply and should be borne in mind when interpreting the outputs. The additional scenarios are presented merely to explore a confidence range around the base-line forecasts, rather than to provide any new firm predictions. Since the model outputs trip production figures for Exeter and Greater Exeter, these are converted into destination trips for completeness.

6.5.2 **High Case (Scenario 2):** Under the scenario 2 which considered an increasingly mobile retired population enabled by technology, it was forecast that trip production by 2040 could reach 270,000 (46% growth from 2011). Under this scenario demand for trips into Exeter would be ~108,000 (44% growth) and ~133,000 (38.9% growth) into Greater Exeter.

Production Zone	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	61,037	71,565	80,793
Greater Exeter Trips	120,594	132,690	148,753	171,495	189,369
Study Area Total	**168,661**	**185,220**	**209,790**	**243,060**	**270,162**

Table 19: High Case (Scenario 2) home to work trip production by origin zone

From Home	To Work	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Exeter	37,974	37,667	43,767	51,316	57,933
Greater Exeter		22,718	27,426	30,746	35,447	39,141
Outside		6,766	9,725	9,452	10,046	10,640
Total		**67,458**	**74,818**	**83,966**	**96,809**	**107,714**

Table 20: Forecast travel demand into Exeter under Scenario 2

From Home	To Work	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Greater Exeter	6,812	7,535	8,755	10,265	11,589
Greater Exeter		78,893	71,329	79,964	92,189	101,797
Outside		13,116	16,907	16,433	17,465	18,498
Total		**98,821**	**95,771**	**105,152**	**119,920**	**131,884**

Table 21: Forecast travel demand into Greater Exeter under Scenario 2

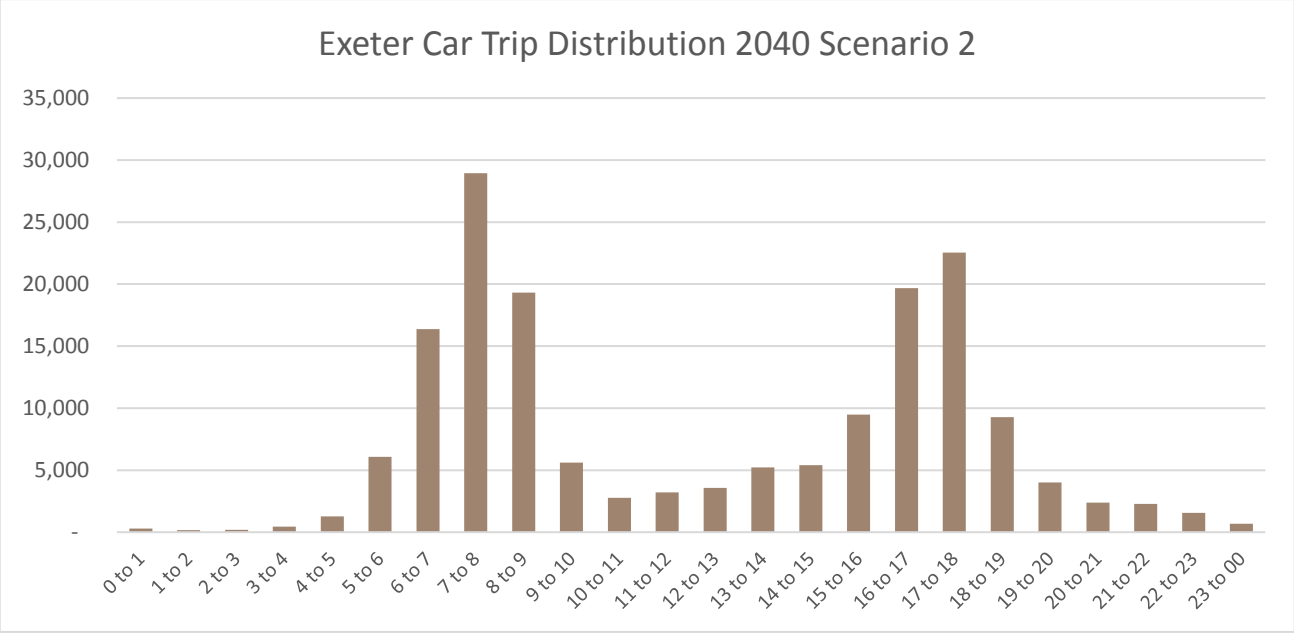

Figure 31: Exeter car trip distribution 2040 scenario 2

6.5.3 **Low Case (Scenario 3):** Scenario 3 considered a reduction to trip rates that was implemented through the car ownership variable within model 2. The implementation effectively resulted in a dampening of trips in Exeter and Greater Exeter. As a result, under this scenario, trip production would be as low as 192,500 (4% growth from 2011) in 2040.

6.5.4 Despite this lower growth, trips into Exeter under this scenario are forecast to grow 10.6%. This is because in the Exeter trip production, population growth plays a much greater factor than the reduction due to car ownership. In this scenario, trips into Greater Exeter are forecast to remain largely unchanged.

Production Zone	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	58,261	61,846	64,826
Greater Exeter Trips	120,594	132,690	138,036	133,986	127,747
Study Area Total	**168,661**	**185,220**	**196,297**	**195,832**	**192,573**

Table 22: Low Case (Scenario 3) home to work trip production by origin zone

From Home	To Work	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Exeter	37,974	37,667	41,776	44,347	46,484
Greater Exeter		22,718	27,426	28,531	27,694	26,404
Outside		6,766	9,725	9,452	10,046	10,640
Total		**67,458**	**74,818**	**79,760**	**82,087**	**83,528**

Table 23: Forecast travel demand into Exeter under Scenario 3

From Home	To Work	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter	Greater Exeter	6,812	7,535	8,357	8,871	9,299
Greater Exeter		78,893	71,329	74,203	72,026	68,672
Outside		13,116	16,907	16,433	17,465	18,498
Total		**98,821**	**95,771**	**98,993**	**98,362**	**96,468**

Table 24: Forecast travel demand into Greater Exeter under Scenario 3

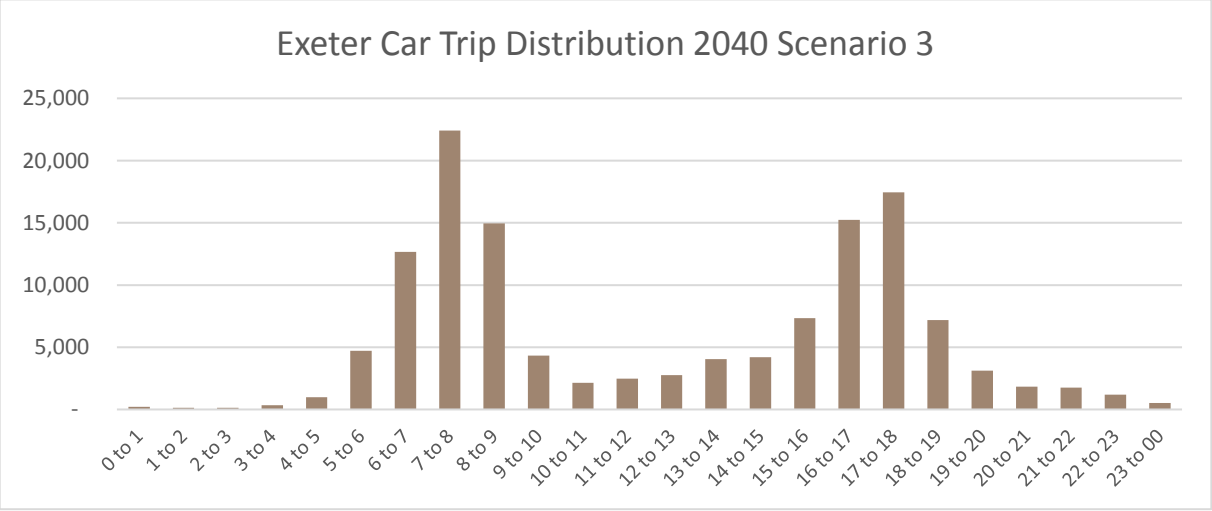

Figure 32: Exeter car trip distribution 2040 scenario 3

6.5.5 Trend Case (Scenario 4):

Scenario 4 assumes that trends observed between 2001 and 2011 continue linearly into the future. The outputs of this scenario are presented below against the base-line Plateau scenario. It can be observed that this scenario forecasts a slightly higher trip generation for the study area as a whole for each year of forecast. Predictions of trips in Exeter are 7% lower, with those for Greater Exeter 8% higher.

Scenario 4	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	58,775	63,667	68,069
Greater Exeter Trips	120,594	132,690	144,391	157,794	169,857
Study Area Total	**168,661**	**185,220**	**203,166**	**221,461**	**237,926**

Table 25: Trend Case (Scenario 4) home to work trip production by origin zone

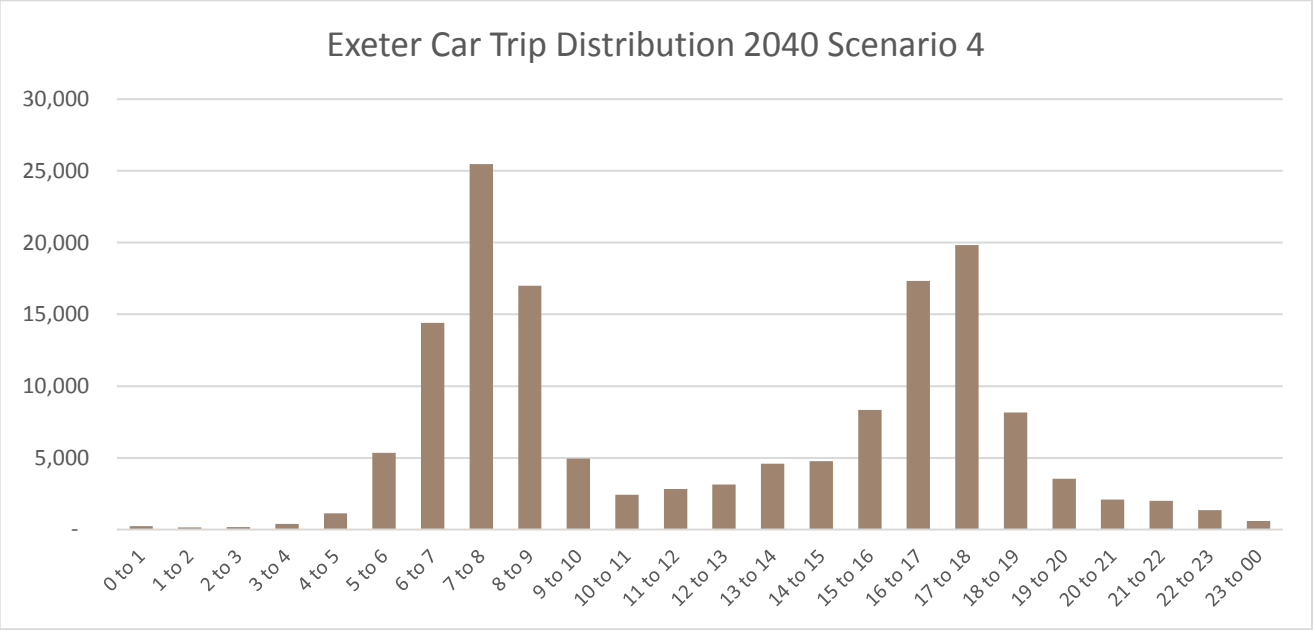

Figure 33: Exeter car trip distribution 2040 scenario 4

Scenario 1	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	48,067	52,530	59,773	67,139	73,521
Greater Exeter Trips	120,594	132,690	143,272	152,316	157,862
Study Area Total	**168,661**	**185,220**	**203,045**	**219,455**	**231,383**

Table 26: Scenario 1 home to work trip production by origin zone

Difference	2001 Trips	2011 Trips	2021 Trips	2031 Trips	2040 Trips
Exeter Trips	0	0	-2%	-5%	-7%
Greater Exeter Trips	0	0	1%	4%	8%
Study Area Total	0	**0**	**0%**	**1%**	**3%**

Table 27: Difference between Scenario 1 and 4

6.5.6 Summary of all scenarios hourly trip rates in 2040

Time	Scenario 1	Scenario 2	Scenario 3	Scenario 4
0 to 1	249	280	217	246
1 to 2	156	175	136	154
2 to 3	164	185	143	162
3 to 4	400	449	348	395
4 to 5	1136	1277	988	1123
5 to 6	5411	6080	4705	5349
6 to 7	14571	16371	12670	14404
7 to 8	25763	28946	22401	25467
8 to 9	17200	19325	14955	17002
9 to 10	4992	5609	4341	4935
10 to 11	2456	2760	2136	2428
11 to 12	2862	3215	2488	2829
12 to 13	3174	3566	2760	3137
13 to 14	4647	5221	4041	4594
14 to 15	4817	5412	4188	4761
15 to 16	8443	9486	7341	8345
16 to 17	17523	19688	15236	17322
17 to 18	20056	22534	17439	19826
18 to 19	8254	9273	7176	8159
19 to 20	3574	4015	3107	3533
20 to 21	2117	2378	1841	2092
21 to 22	2029	2280	1764	2006
22 to 23	1377	1548	1198	1362
23 to 00	605	680	526	598

Table 28: Expected hourly movements into Exeter

6.6 Results: Conclusion

6.6.1 Trip growth scenarios under the base-case Plateau Scenario and under the current trends scenario show close alignment. The majority of forecasts, even those adjusted to align with NTEM in the base-year show an increase in trips generated compared to NTEM. Additional scenarios have been presented that begin to explore the limits of the travel demand that could be anticipated out to 2040, but even in these cases, forecast growth emerges as higher than NTEM.

7 Methodological Notes

7.1 Geographical Definition

7.1.1 The main area of this study consists of the Greater Exeter region which consists of the following district authorities: Exeter, Mid Devon, East Devon and Teignbridge. Throughout this report we refer to the geographies as follows:

- **Exeter:** Exeter City Council region
- **Greater Exeter:** The ring of local authority areas surrounding Exeter, excluding the city itself
- **Study Area:** The combined area comprising the 4 local authorities, shown in orange below.
- **Outside the Study Area:** England and Wales excluding the study area.
- **Travel to Work Area:** The area defined by the ONS in the 2011 census as the Travel to Work Area for Exeter[9].

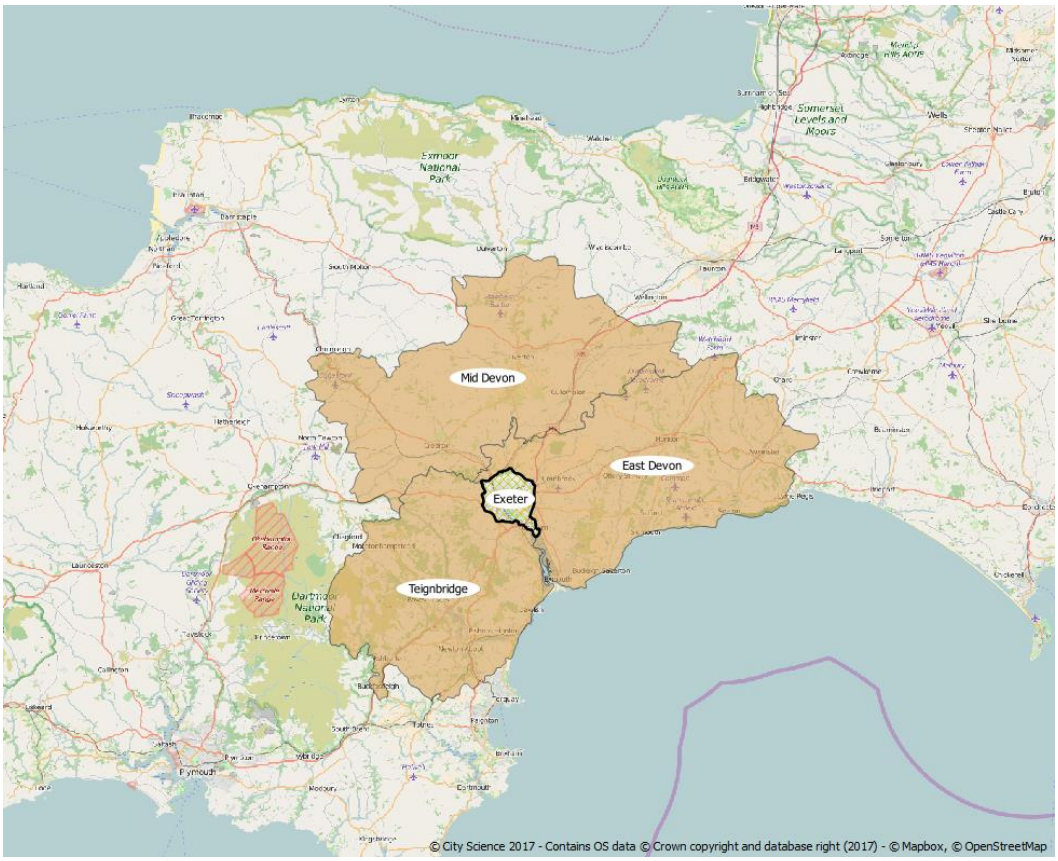

Figure 34: Map of study area

[9] http://ons.maps.arcgis.com/apps/MapSeries/index.html?appid=397ccae5d5c7472e87cf0ca766386cc2

7.2 Part 1: Historical Trends

7.2.1 Overview

Part 1 provides an overview and comparison of commuting travel patterns as described in the 2001 and 2011 census. It then provides an updated comparison with the most recent demand data obtained by City Science. Due to collection methods, minor differences are observed based on the methodology employed. The data sources and methods are described below.

7.2.2 Census Data collection

The main data used in Part 1 is obtained from the 2001 and 2011 census. Geographical information for census responses is captured on usual address and workplace address. The collection of modal information in both 2001[10] and the 2011[11] is via the census question "What was your main mode of travel to work". The ONS calibrates the travel to work question to allow comparability with the 2001 census based on the following priority: workplace address information is prioritised over method of travel when identifying home workers.

7.2.3 Between 2001 and 2011 the categorisation of "working from home" was changed. In 2001 OD pairs associated with the classification 'work from home' were shown as having the same origin and destination. In 2011, this was changed with destination codes for these workers being prefixed with 'OD'. Working from home trips are not immaterial being respectively 9% and 10% of total trips nationally in 2001 and 2011.Throughout this report we adopt two approaches to "working from home" trips.

7.2.4 First approach – destination-based analysis

For our analysis of destinations and for the model development, working from home trips are excluded. This is for two reasons: 1) we cannot say categorically where working from home trips are going and 2) excluding working from home trips in our forecasts ensures that outputs are comparable at the total trip level with Tempro. In the main part of the document, unless stated otherwise, assume that working from home trips have been removed.

7.2.5 Second approach – origin-based analysis:

The analysis of origins includes all trips described as "working from home" and associates these in both time periods and treats the destination as being the same as the origin in which they are recorded. A number of census trips in both 2001 and 2011 are described as having 'no fixed place of work'. In 2011, where these trips relate to 'working from home' they are included within the codes with an 'OD' prefix described above. In our tables, those working from home with no fixed

[10] https://www.ons.gov.uk/census/2011census/2011censusdata/2001censusdata
[11] https://www.ons.gov.uk/census/2011census

place of work are shown as having the same destination as their origin. In Appendix 1, unless stated, assume that working from home trips are included.

7.2.6 **Data sources for 2001**

ONS Census 2001 data at the OA level was forwarded by the ONS via email on 13th February 2017. As a sense check, the total number of trips for England and Wales in this document was shown to be 24,034,955. 2001 data at an LAD level was also available for England from Nomis. Two methods were employed processing both of these datasets to view the information across the study area. Validation was then achieved by comparing these results. The comparison tables are included in Appendix 1. Both files contain modal share data. The results from the different source files are also included in the Appendix.

7.2.7 **Data sources for 2011**

For 2011, granular data is available online. OA level data can be downloaded from the following link:
http://webarchive.nationalarchives.gov.uk/20160105160709/http://nomisweb.co.uk/census/2011/origin_destination. There are a number of files of relevance. WF01BEW provides the location of usual residence and place of work at the OA level but excludes modal information. WF02EW provides the location of usual residence and place of work (with outside UK collapsed) showing destinations under the Work Place Zone geography that was new in 2011. Modal information is provided at the MSOA level and upwards. Trips can therefore be attained at MSOA and LAD. The LAD file shows all origins and destinations for the whole of the UK, while the MSOA file is England and Wales only.

7.2.8 We have calculated the total trips based on the LAD file but show two versions – whole of UK and England and Wales only to be comparable with 2001. It should be noted that processing down the whole UK LAD file produces slightly more trips (53,627) for England and Wales than shown in the raw MSOA file. A comparison between analysis of the unadjusted LAD UK file and the adjusted version is shown in the Appendix.

7.2.9 The ONS do not distinguish cars and vans; hence for this report outbound commuting trips by car mode is taken as all respondents who indicated that they drove to work, or were a passenger in a car or van. Travel to work by 'non-car' mode therefore aggregates the following modes; intra-city rail/tram, inter-city train, bus, taxi, motorcycle, scooter or moped, bicycle and by foot.

7.2.10 **Travel to work area**

It is stated that Exeter has the second largest travel to work area in the UK and therefore an analysis by Travel to Work area was considered for the Exeter study. The production of trips for Greater Exeter extends beyond the travel to work area defined by ONS. It was considered more appropriate a wider geography when examining trip productions to Exeter.

7.3 Use of Mobile Network Data

7.3.1 **2016 comparison**

In order to provide additional data, beyond that available in the Census, City Science provides an overview of the data collected as part of a study undertaken in 2016. This data is compared against the outputs from the analysis of census information. It is anticipated that this data can provide some up-to-date insights into the current travel patterns, but significant differences in collection and processing methodology exist that restrict the direct comparisons that can be made. The collection of this data and the relevant differences are explained below.

7.3.2 Mobile network data uses aggregated and anonymised cellular connection events to identify the zones in which mobile devices reside over time. Intermediate providers process this data on behalf of the mobile network operators and deliver origin-destination matrices in a format for use within traditional transport models.

7.3.3 Increasingly mobile network data is being used alongside traditional data to inform transport modelling. Given the penetration of mobile phones within the general population, and the market shares of the companies offering this service, the sample rates for mobile network data are high (often 20-30% of the population). This offers a potentially strong advantage against other local data collection types.

7.3.4 Mobile phone demand data were collected by Citilogik under license to City Science during 2016. The period of data capture covered the two week periods either side of the 2016 Easter holidays. The sample therefore combined: Week 1 & 2: Thursday, 10 March 2016 to Thursday, 24 March 2016 and Week 3 & 4: Monday, 11 April 2016 to Sunday, 24 April 2016. The collection was undertaken using a geo-fence that extended across Devon and Cornwall. LSOA level resolution was provided within a 50 km radius of the centre of Exeter and MSOA-level resolution was provided beyond this.

Figure 35: Geo-fence for the 2016 mobile data collection

7.3.5 An extensive validation exercise was undertaken by City Science to test the areas in which the dataset was comparable with other sources. A suite of tests comparable with those used on the Regional Transport Models were conducted for internal consistency (matrix symmetry), trip rates, mode split, spatial distribution, journey length, daily profile and purpose profiles. Based on this work and our understanding of the underlying process, the most relevant comparisons and inferences are provided.

7.4 Part 2: Time of Day

7.4.1 The aim of this section is to allocate commuting trips to the relevant time profiles from the National Travel Survey to arrive at an 'order of magnitude' estimate for the car and non-car demand across an average day. Geographically, profiles were applied to all inbound trips to Exeter, outbound trips and trips within the city to give a general level of traffic on the road.

7.4.2 Commuting trips are anticipated to have a symmetry such that the NTS data includes both 'home to work' and 'work to home' legs, while the census only captures the indicated 'home to work' outbound trip. To estimate the peak hour trips from the census therefore, total census trips have been doubled and allocated across the time-buckets exhibited by the national travel survey. Annual leave, sick days and working from home days should also be considered. These factors are dealt with in the adjusted models that compare to NTEM but not adjusted in the Time of Day section.

7.4.3 The process is indicative only and does not consider the following:

- Commuters that have no fixed routine, or work from home a number of days per week. These commuters may have responded to the census as having a fixed destination, but the overall traffic would be observed to be lower due to the distribution of days actually worked.
- Non-commuting traffic, such as Light Goods Vehicles, which may be on the road at a particular time of day, and impact the overall volumes.
- Some traffic will use radial / arterial routes with an eventual destination outside of the city. This is not captured by the census response and will not be accounted for in the allocation to time of day.
- The NTS regional data was explored for departure times. The arrival time into Exeter will vary depending on where the trip originates from. No adjustment has been made to account for this time shift which may have a material impact on observed flow.

7.5 Part 3: Future Projections

7.5.1 Future projections are based on trip rates. Trip rates are defined as the ratio of the number of trips originating from an LSOA to the population of the LSOA. The population data was obtained from the ONS Lower Super Output Area Population Estimates for 2011, while the number of trips was aggregated from the ONS origin-destination tables, documenting the location of usual residence and place of work for individuals in England and Wales.

7.5.2 City Science sourced a number of additional datasets from the ONS which were brought together at LSOA level. The main additional datasets used were population data, data regarding economically active populations, socio-economic classifications provided in the census (NS-SeC tables), availability of cars and vans. This information was also processed spatially to arrive at additional relevant variables e.g. density.

7.5.3 A number of sensitivities are then explored using the 2001 and 2011 data to inform possible modelling approaches. Relevant data analysis and a brief review of literature relevant to technological change is also presented. At this stage some simple models were explored to test and develop a range of growth scenarios.

7.5.4 In certain cases, raw ONS data was simplified to explore relationships at a high-level. In particular to conduct the investigation into socio-economic categories, 9 ONS categories were reduced to 4 via the following approach. Long-term unemployed were extracted to sit within their own class (Class 4) on the basis that this demographic exhibits a different trip production rate than other workers. Class 1 grouped together managerial and higher professional occupations. Class 3 was built to take account of professions described as routine and semi-routine, while Class 2 was used to group together remaining categories.

7.5.5 Based on a sub-set of 8 variables that exhibited observable trends a multi-variable model was developed. 7 variables were fitted based on linear relationships, while the curvature observed in trip-rates based on mean age was modelled with a minus square relationship. Fitting parameters were obtained and then applied to the 8 variables by LSOA. LSOA trip results were then aggregated to Exeter and Greater Exeter. Trips production from outside the study area were modelled equivalently to Model 1 (based on Trip rates).

7.5.6 The model was then implemented in Excel. The Excel based model calculates near-equivalent results to the Python code based on an average LSOA profile for Exeter and Greater Exeter. The average trip generation is then scaled up to Exeter and Greater Exeter based on the number of LSOAs. The difference in implementation results in a discrepancy between most forecasts of +/- 1,000 trips.

7.5.7 For completeness, the scenario-based extrapolations are compared with the trip production outputs from the National Trip End Model. Here LAD trip estimates were extracted via the TEMPRO software, with comparable modes selected.

CITY SCIENCE
endless possibilities

8 Appendix

2001 Data

Methodology & Data Source Reported

OA England & Wales

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	2,160	4,760	18,479	2,782	21	652	84	147	178	8,711	4,003	41,977
Exeter	Greater Exeter	156	384	5,357	546	3	132	12	15	78	129	0	6,812
Exeter	Outside	54	144	2,372	231	36	12	39	3	156	234	0	3,281
Greater Exeter	Exeter	237	1,150	18,319	1,569	3	381	15	18	814	212	0	22,718
Greater Exeter	Greater Exeter	2,404	2,357	51,088	5,766	6	1,349	690	240	342	14,651	20,154	99,047
Greater Exeter	Outside	129	438	15,955	946	78	288	99	12	519	519	0	18,983
Outside	Exeter	42	285	5,623	294	15	63	30	15	207	192	0	6,766
Outside	Greater Exeter	114	393	10,887	846	9	279	87	18	117	366	0	13,116
Total Trips		**5,296**	**9,911**	**128,080**	**12,980**	**171**	**3,156**	**1,056**	**468**	**2,411**	**25,014**	**24,157**	**212,700**

LAD Table (England)

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	2,116	4,499	18,258	2,701	18	723	110	130	210	9,196	4,016	41,977
Exeter	Greater Exeter	137	349	4,942	543		135	17	7	96	142		6,368
Exeter	Outside	30	135	2,088	163	28	21	39		156	285		2,945
Greater Exeter	Exeter	221	1,223	17,899	1,544	8	449	34	21	800	271		22,470
Greater Exeter	Greater Exeter	2,194	2,113	49,401	5,926	13	1,252	735	289	404	15,111	20,214	97,652
Greater Exeter	Outside	119	405	14,809	884	81	286	100	12	435	582		17,713
Outside	Exeter	58	256	5,481	344	24	64	23	14	190	209		6,663
Outside	Greater Exeter	95	293	9,935	871	12	274	103	20	140	353		12,096
Total Trips		**4,970**	**9,273**	**122,813**	**12,976**	**184**	**3,204**	**1,161**	**493**	**2,431**	**26,149**	**24,230**	**207,884**

CITY SCIENCE
endless possibilities

2011 Data

Methodology & Data Source Reported

LAD UK (processed down to England & Wales)

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	3,165	4,325	15,272	2,091	8	528	61	104	480	11,633	4,897	37,667
Exeter	Greater Exeter	228	563	5,506	516	1	117	22	20	174	388	0	7,535
Exeter	Outside	160	324	5,066	385	44	55	123	71	437	663	0	12,225
Greater Exeter	Exeter	548	1,722	21,338	1,628	12	416	35	23	1,353	351	0	27,426
Greater Exeter	Greater Exeter	2,042	1,911	45,891	4,573	11	891	324	209	538	14,939	26,183	71,329
Greater Exeter	Outside	357	623	27,808	1,538	146	302	566	79	1,120	1,396	0	60,118
Outside	Exeter	128	360	7,706	418	23	106	30	9	619	327	0	9,726
Outside	Greater Exeter	176	505	13,526	978	27	266	162	26	379	864	0	16,909
Total Trips		**6,804**	**10,333**	**142,113**	**12,127**	**272**	**2,681**	**1,323**	**541**	**5,100**	**30,561**	**31,080**	**242,935**

LAD UK (Raw)

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	3,165	4,325	15,272	2,091	8	528	61	104	480	11,633	0	37,667
Exeter	Greater Exeter	228	563	5,506	516	1	117	22	20	174	388	0	7,535
Exeter	Outside	160	324	5,066	385	44	55	123	71	437	663	4,897	12,225
Greater Exeter	Exeter	548	1,722	21,338	1,628	12	416	35	23	1,353	351	0	27,426
Greater Exeter	Greater Exeter	2,042	1,911	45,891	4,573	11	891	324	209	538	14,939	0	71,329
Greater Exeter	Outside	357	623	27,808	1,538	146	302	566	79	1,120	1,396	26,183	60,118
Outside	Exeter	130	360	7,713	418	23	106	33	9	620	330	0	9,742
Outside	Greater Exeter	176	511	13,552	990	27	266	171	28	383	888	0	16,992
Total Trips		**6,806**	**10,339**	**142,146**	**12,139**	**272**	**2,681**	**1,335**	**543**	**5,105**	**30,588**	**31,080**	**243,034**

CITY SCIENCE
endless possibilities

Python Export 2011 (LAD UK reduced to England and Wales)

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	3,165	4,325	15,272	2,091	8	528	61	104	480	11,633	4,897	37,667
Exeter	Greater Exeter	228	563	5,506	516	1	117	22	20	174	388	0	7,535
Exeter	Outside	160	324	5,066	385	44	55	123	71	437	663	0	12,225
Greater Exeter	Exeter	548	1,722	21,338	1,628	12	416	35	23	1,353	351	0	27,426
Greater Exeter	Greater Exeter	2,042	1,911	45,891	4,573	11	891	324	209	538	14,939	26,183	71,329
Greater Exeter	Outside	357	623	27,808	1,538	146	302	566	79	1,120	1,396	0	60,118
Outside	Exeter	128	360	7,706	418	23	106	30	9	619	327	0	9,726
Outside	Greater Exeter	176	505	13,526	978	27	266	162	26	379	864	0	16,909
Outside	Outside	737,964	1,910,179	14,395,279	1,326,540	998,254	206,802	131,797	128,332	1,322,807	2,582,580	2,751,726	26,492,260
Total Trips		**744,768**	**1,920,512**	**14,537,392**	**1,338,667**	**998,526**	**209,483**	**133,120**	**128,873**	**1,327,907**	**2,613,141**	**2,782,806**	**26,735,195**

Python Export 2011 (England & Wales MSOA Basis built up to LAD)

OriginZone	DestZone	bicycle	bus	car_driver	car_passenger	metro_tram	motorcycle	other	taxi	train	walk	work_from_home	total_trips
Exeter	Exeter	3,165	4,325	15,272	2,091	8	528	61	104	480	11,633	0	37,667
Exeter	Greater Exeter	228	563	5,506	516	1	117	22	20	174	388	0	7,535
Exeter	Outside	160	324	5,066	385	44	55	123	71	437	663	4,897	12,225
Greater Exeter	Exeter	548	1,722	21,338	1,628	12	416	35	23	1,353	351	0	27,426
Greater Exeter	Greater Exeter	2,042	1,911	45,891	4,573	11	891	324	209	538	14,939	0	71,329
Greater Exeter	Outside	357	623	27,808	1,538	146	302	566	79	1,120	1,396	26,183	60,118
Outside	Exeter	128	360	7,705	418	23	106	30	9	619	327	0	9,725
Outside	Greater Exeter	176	505	13,525	978	27	266	161	26	379	864	0	16,907
Outside	Outside	737,655	1,906,371	14,364,008	1,318,728	998,254	206,559	130,316	127,892	1,322,093	2,579,821	2,746,939	26,438,636
Total Trips		**744,459**	**1,916,704**	**14,506,119**	**1,330,855**	**998,526**	**209,240**	**131,638**	**128,433**	**1,327,193**	**2,610,382**	**2,778,019**	**26,681,568**

Car trip rates 2001 and 2011

OriginZone	year	population	trip rates
Exeter	2001	102,403	0.26
Exeter	2011	117,773	0.22
Greater Exeter	2001	314,195	0.27
Greater Exeter	2011	334,427	0.28
Outside	2001	50,292,117	0.26
Outside	2011	55,623,712	0.26

First Order population-based model

OriginZone	year	population	α (plateau)	demand (plateau)	α (trend)	demand (trend)
Exeter	2001	102,403	0.26	26,208	0.26	26,208
Exeter	2011	117,773	0.22	25,844	0.22	25,844
Exeter	2021	131,000	0.22	28,746	0.18	23,966
Exeter	2031	140,000	0.22	30,721	0.15	20,504
Exeter	2039	146,000	0.22	32,038	0.11	16,055
Greater Exeter	2001	314,195	0.27	85,362	0.27	85,362
Greater Exeter	2011	334,427	0.28	95,037	0.28	95,037
Greater Exeter	2021	361,000	0.28	102,588	0.30	107,098
Greater Exeter	2031	384,000	0.28	109,124	0.31	118,719
Greater Exeter	2039	399,000	0.28	113,387	0.32	128,342
Outside	2001	50,292,117	0.26	13,321,764	0.26	13,321,764
Outside	2011	55,623,712	0.26	14,385,238	0.26	14,385,238
Outside	2021	54,065,000	0.26	13,982,128	0.25	13,643,102
Outside	2031	57,461,000	0.26	14,860,391	0.25	14,139,749
Outside	2039	59,748,000	0.26	15,451,849	0.24	14,327,862

CITY SCIENCE
endless possibilities

2001 Mode Share: Results from different datasets

Source: England Nomis File

Mode	All Responses	Exeter	Greater Exeter	Study Area
bicycle	2.9%	4.5%	1.8%	2.5%
bus	6.6%	9.7%	2.7%	4.6%
car_driver	54.5%	49.3%	59.6%	56.8%
car_passenger	5.7%	6.6%	6.1%	6.2%
metro_tram	3.8%	0.1%	0.1%	0.1%
motorcycle	1.2%	1.7%	1.4%	1.5%
other	0.4%	0.3%	0.6%	0.5%
taxi	0.5%	0.3%	0.2%	0.2%
train	5.0%	0.9%	1.2%	1.1%
walk	9.9%	18.8%	11.6%	13.5%
work_from_home	9.6%	7.8%	14.7%	12.8%
total_trips	**100.0%**	**100%**	**100%**	**100%**

Source: England & Wales Bulk Download

Mode	All Responses	Exeter	Greater Exeter	Study Area
bicycle	2.7%	4.6%	2.0%	2.7%
bus	7.7%	10.2%	2.8%	4.8%
car_driver	56.1%	50.3%	60.6%	57.9%
car_passenger	6.2%	6.8%	5.9%	6.1%
metro_tram	3.1%	0.1%	0.1%	0.1%
motorcycle	1.0%	1.5%	1.4%	1.5%
other	0.3%	0.3%	0.6%	0.5%
taxi	0.5%	0.3%	0.2%	0.2%
train	4.0%	0.8%	1.2%	1.1%
walk	9.4%	17.4%	10.9%	12.7%
work_from_home	9.0%	7.7%	14.3%	12.5%
total_trips	**100.0%**	**100%**	**100%**	**100%**